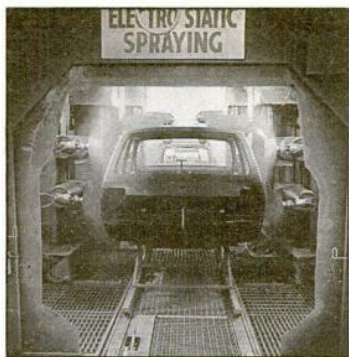








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This week's cover by Simon Larbalestier

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The cost of whaling
Evolution beyond Darwin

Robert Mason

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This One



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Appointments and situations vacant

What can science and engineering graduates teach the Royal Navy?

As an Instructor Officer, with a science or engineering degree, the Royal Navy can learn a great deal from you.

It will be your job to provide the training expertise that the Navy needs, at all levels, from elementary to postgraduate.

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There are opportunities for you to develop into a number of specialist fields.

For example, with a science background you could well find yourself being trained to provide the Navy with oceanographic and meteorological forecasts ashore and afloat. Or you could be selected for computer systems training and eventually be instructing and working on advanced computer systems.

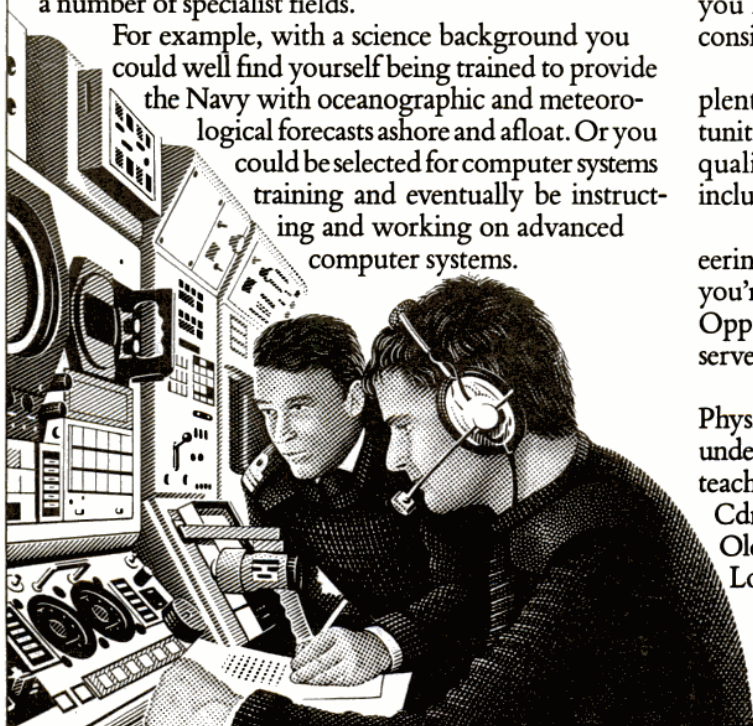
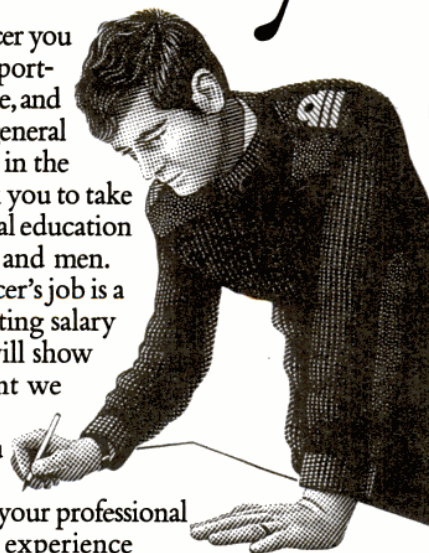
As an Officer you will also have an important management role, and be involved in the general organisation of life in the Navy. We'll also ask you to take charge of the general education of serving officers and men. An Instructor Officer's job is a vital one and a starting salary of up to £13,200 will show you how important we consider it to be.

We'll give you plenty of opportunities to enhance your professional qualifications and experience including postgraduate courses and research.

So if you want to make the most of your Engineering or Science qualifications and experience, and you're not looking for a nine-to-five job, talk to us. Opportunities exist for women, as WRNS Officers, to serve as Instructor Officers.

You should have a degree in Engineering, Physics, Maths or Computer Sciences, and be under 34, under 25 for women. You don't need to be a teacher, we'll teach you. For more information, write to Cdr A. J. Prosser, BSc, RN, Dept. 787, Old Admiralty Building, Spring Gardens, London SW1A 2BE.

Normally you should have been a UK resident for the past five years.



Serono
DIAGNOSTICS

Immunoassay R&D

Project Leader

This is an excellent opportunity for a young immunoassay specialist, perhaps at Development Scientist level now, to join a young, dynamic team at a more senior level—with excellent prospects for further advancement. Our clients, Serono Diagnostics, are the UK subsidiary of an innovative and highly successful health care organisation. As a result of internal career development, they now seek a Project Leader within their hormone immunoassay R&D group.

Reporting to the R&D Manager, the successful candidate will be responsible for leading a major development project, expanding the MAIAclone product range. The work will include all aspects of product development from feasibility to launch, and will involve close liaison with the Process Development Group and Marketing.

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Leaders in Health Care Recruitment



Attractive salary package

Applicants, ideally in their late 20s/early 30s, should be qualified to at least first degree level and have several years' experience of hormone immunoassays in conjunction with the use of radioisotope or enzyme labels. Experience of labelled antibody techniques would be a distinct advantage. Personal attributes should include scientific and innovative skills, coupled with considerable organisational ability.

An attractive salary package is offered, and additional benefits include 23 days' annual holiday, free private medical insurance and generous relocation expenses, if required.

Please write in confidence for an application form, or 'phone if you would like to discuss the post further before applying:

Bryan J Oswald, Talentmark Limited,
King House, 5-11 Westbourne Grove,
London W2 4UA. Tel: 01-229 2266.

nature

the international journal of science
requires an

ASSISTANT EDITOR

in the

BIOLOGICAL SCIENCES

Duties: For an initial period of at least six months in the London office, to assist in the preparation of manuscripts for the press, thereafter to play a wider part in the editorial process.

Essential qualifications: Good first degree in biological science, research experience and a sense of literacy. Preference will be given to applicants with first-hand experience of molecular and cell biology, proven capacity to write well and a broad interest in science.

Candidates should send a full cv and supporting materials together with the names of two referees to the Editor, *Nature*, 4 Little Essex Street, London WC2R 3LF, to arrive by 16 June, 1986.



INFORMATION SCIENTIST

Our Legislation Section at the Leatherhead Food Research Association has a worldwide reputation for the provision of fast and accurate information concerning Food Legislation. The growth in the number of enquiries from the food industry has led to a requirement for an Information Scientist to join a busy team, providing information on overseas food legislation, (food additives, composition, labelling etc) to member companies.

This work will involve scanning official documents to extract relevant details, preparing information sheets, updating manuals and processing legal information for computerisation.

The successful candidate is likely to have recently obtained a good degree in Food Science or Chemistry. An understanding of German and previous work experience would be an advantage. Full training will be given but a genuine interest in helping with professional problems, excellent communication skills and the ability to work under pressure from time to time are prerequisites.

In return, we offer a competitive salary with excellent opportunities for career progression.

Please write with career details to Susan Wilband, Personnel Manager, Leatherhead Food Research Association, Randalls Road, Leatherhead, Surrey KT22 7RY, telephone Leatherhead 376761.

Allied Breweries Limited, the beer division of Allied-Lyons PLC, is a major company within the drinks industry engaged in the production, distribution and retailing of such leading brands as Skol, Long Life, Double Diamond and Castlemaine XXXX and a wide range of regional ales.

Senior Research Scientist

A vacancy exists for a Senior Research Scientist to carry out projects in the Product & Process Investigation Section of the department. The work will be primarily associated with the biochemistry of the malting process and raw materials used in brewing.

Applicants should possess a good honours degree in biochemistry or plant physiology and should have at least three years post graduate research experience. A research degree would be advantageous.

An attractive salary will be offered together with the benefits normally associated with a large company.

The position is based in Burton-upon-Trent and assistance with relocation expenses will be offered where appropriate.

Please write or telephone for an application form to: Mrs. C. M. Lane,



ALLIED BREWERIES

Personnel & Training Officer,
Allied Breweries Limited,
107 Station Street,
Burton-upon-Trent, Staffordshire
DE14 1BZ.
Telephone: Burton-upon-Trent
(0283) 45320 ext. 2309.

IMPERIAL CANCER RESEARCH FUND

Edinburgh

SENIOR TECHNICIAN

required by our Molecular Pharmacology and Drug Metabolism Laboratory based in the Department of Biochemistry, Edinburgh University to undertake the day-to-day running of the laboratory and to assist members of the scientific staff with project work involving the characterisation of human drug metabolising enzyme systems in relation to carcinogenesis and cancer therapy.

HNC or degree. Experience in recombinant DNA techniques an advantage. Salary range £7874-£10 402. For further details and application form write or telephone Mrs P. Harwood, Imperial Cancer Research Fund, Lincoln's Inn Fields, London WC2A 3PX on 01-242 0200, Ext 3205 quoting ref. 87/86.

ST. MARY'S HOSPITAL MEDICAL SCHOOL

(University of London) Norfolk Place, London W2 1PG RESEARCH ASSISTANT

required in the Department of Clinical Pharmacology for a Wellcome Trust funded project involving the development of new cell culture techniques for human vascular cells. This post will be for two years in the first instance. Experience in mammalian cell culture highly desirable. Salary up to £8020 plus London Allowance, depending on qualifications and experience.

Applications in writing with detailed cv and names of two referees, to Assistant Secretary (Personnel) at the above address no later than 14 June, 1986.

RIVERSIDE HEALTH AUTHORITY

Charing Cross Hospital

SENIOR GRADE PHYSICIST

required for the Nuclear Medicine Department to join two principal grade physicists as part of scientific support for work with radionuclides in the hospital and medical school. Experience in nuclear medicine and associated computer techniques is essential and experience in radiation protection of unsealed sources would be an advantage. Involvement in scientific development work undertaken within the department will be actively encouraged.

Applicants must have a First or Second Class honours degree in physics.

Salary: £11 165-£14 237 pa inclusive. For informal discussions/further details and application forms contact Mr J. Jeyasingh or Miss B. E. Jones on 01-748 2040 Ext 2412/2411.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

(University of London)

RESEARCH ASSISTANT

Postdoctoral or experienced post-graduate required as soon as possible to work until July 1987 on SERC-sponsored research project on western Pacific marine minerals. Experience in deep sea marine geology/geochemistry and/or deep sea floor site investigations essential, and experience in computing and processing of marine geological/geochemical data would be an advantage.

Salary on scale £8352-£14 077 including London Allowance. Apply to Dr D. S. Cronan, Department of Geology, Imperial College, London SW7 2BP.

UNIVERSITY OF LIVERPOOL

CHAIR OF EXPERIMENTAL PHYSICS

Applications are invited for the Chair of Experimental Physics which will become vacant in June 1986, on the retirement of Prof L. L. Green.

The Department of Physics has an established reputation in the fields of Nuclear Structure Physics, High Energy Physics and Solid State Physics. Applications are invited from suitable candidates with particular interests in the field of Nuclear Physics.

The salary will be within the range approved for non-clinical professorial salaries, currently not less than £19 918 pa (under review). Applications, together with the names of three referees should be received not later than 31 August, 1986, by the Registrar, The University, PO Box 147, Liverpool L69 3BX, from whom further particulars may be obtained.

Quote Ref. RV/763/NS.

THE MIDDLESEX HOSPITAL MEDICAL SCHOOL

The School of Pathology

MLSO

A temporary MLSO is required to the end of the year to assist with a dietary experiment involving the feeding of vitamin A containing diets to mice. Applicants should have previous experience of animal husbandry and maintenance. Salary on the MLSO scale, £7141-£9127, pro rata, according to age and experience. Apply by letter, including a cv and the names of two work-related referees, to Prof R. M. Hicks, School of Pathology, The Middlesex Hospital Medical School, Mortimer Street, London W1P 7PN.

UNIVERSITY OF OXFORD DEPARTMENT OF BIOCHEMISTRY

THE CANCER RESEARCH CAMPAIGN CHROMOSOME MOLECULAR BIOLOGY GROUP

POSTDOCTORAL POSITIONS-Grade 1A

Ref: BC/154

Two postdoctoral positions are available in a group working on the molecular biology of mammalian chromosomes in normal and cancer cells. Areas of research include: development and application of techniques for mapping the DNA of whole mammalian chromosomes, characterisation of the DNA in the human centromeric regions, identification of proteins associated with specific chromosomal regions, construction of minichromosomes as vectors for mammalian cells. Both positions are for three years on the salary scale of £8020-£12 780 and are available immediately. Applicants should have or expect shortly a PhD or equivalent degree.

Technician Grade 3

A technician is required to join a small group studying the structure of DNA in the region of the Duchenne Muscular Dystrophy locus. The work will involve microbial and molecular biology techniques and training will be provided where necessary. The post is initially for one year but may be renewed annually, and is available immediately.

Applicants should be qualified to OTEC/ONC standard and have at least three years relevant experience.

Salary on the scale £5682-£6657 pa.

Three copies of applications with CV and names of at least two referees should be sent to:

The Administrator
University of Oxford
Department of Biochemistry
South Parks Road
Oxford OX1 3QU

The closing date is 27 June, 1986.

THE UNIVERSITY OF SHEFFIELD

DEPARTMENT OF ZOOLOGY

Temporary Lecturer

Applications are invited from men and women for this post in the field of comparative animal physiology, tenable from 1 September, 1986 for one year. The successful candidate will be expected to teach in undergraduate programmes, at all levels, but will be given opportunity for personal research. Areas of particular interest are invertebrate and developmental neurobiology but all candidates with experience in comparative physiology will be considered.

Salary will be in the range £8020-£9495 on the non-clinical lecturers scale, according to age, qualifications and experience.

Further particulars can be obtained from the Personnel Department (Academic Staffing), The University, Sheffield S10 2TN to which applications (six copies) including the names of three referees should be sent to arrive by 16 June, 1986. Please quote reference R.430/H.

DEPARTMENT OF THE ENVIRONMENT

Building Research Establishment Garston, Watford, Herts

The Building Research Establishment carries out a comprehensive research programme in building and fire science to advise and guide Government, industry and owners. It possesses facilities unrivalled in the UK and has an acknowledged reputation and expertise in many

fields. The working environment is stimulating and publication of primary research and reports for the industry is encouraged.

There are currently opportunities in the following areas:

Construction Process

You will lead a team studying building processes including project information and planning, the influence of design upon ease of building and productivity, and the assessment and control of quality of construction.

You should have a 1st or 2nd class honours degree, or equivalent, in an appropriate subject, considerable relevant research experience and experience of team leadership.

The post is at Grade 7 level £13,505-£18,360 (under review) according to qualifications and experience.

For further details and an application form (to be returned by 20 June 1986) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 468551 (answering service operates outside office hours). Please quote ref: S(C)677.

Concrete Technology

You will develop and conduct research into the technology of concrete for application in buildings of all types. The work includes concrete mix designs, quality assurance and control, test methods, influence of constituent materials and normal site or factory practices on performance, particularly durability.

Appointment as Higher Scientific Officer/Senior Scientific Officer. Ref: SA/13/HK.

Building Environmental Analysis

Using your physics/mathematical modelling experience you will lead projects in the field of energy/environmental performance of buildings. These will include validation of thermal simulation models, risks of overheating in offices and evaluation of solar cells.

Appointment as Higher Scientific Officer/Senior Scientific Officer. Ref: SA/14/HK.

Building Defects

You will develop guidance and advice for the building industry to avoid in-built defects. The work will involve observation of buildings during construction, discussions with participants to establish causes of defects and formulation of new procedures.

Appointment as Senior Scientific Officer/Senior Professional and Technology Officer. Ref: SA/15/HK.

Timber Structures

You will study the design and integrity of timber structures, involving the use of structural reliability theory on a statistical basis. You will also provide support and technical expertise to BSI and other committees and assist the BRE Advisory Service.

This post is situated at Princes Risborough but that Laboratory will be moving to the Building Research Station in 1987.

Appointment as Higher Scientific Officer/Senior Scientific Officer. Ref: SA/16/HK.

RELOCATION EXPENSES MAY BE AVAILABLE FOR ALL THESE POSTS.

SALARY AND QUALIFICATIONS:

Higher Scientific Officer: £7785-£10,540 (under review). Degree/HND/HNC or equivalent qualification in an appropriate subject. At least 2 years' post-graduate experience is required for those with a 1st or 2nd class honours degree; at least 5 years' experience with other qualifications.

Senior Scientific Officer: £9770-£12,650 (under review). 1st or 2nd class honours degree or equivalent in an appropriate subject and at least 4 years' post-graduate experience.

Senior Professional and Technology Officer: £11,080-£13,660 (under review). A Chartered Engineer with several years' relevant experience.

In addition the posts at Garston attract £545 Outer London Weighting.

For further information and an application form (to be returned by 20 June 1986) write to Mrs. G. Bright, Building Research Station, Bucknalls Lane, Garston, Watford, WD2 7JR or telephone 0923 674040 ext 235.

Please quote appropriate reference number.

The Civil Service is an equal opportunity employer

Scientific
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THE WORLD HEALTH ORGANIZATION invites applications for a post of

EDITOR

at its Regional Office for South-East Asia in New Delhi, India

The incumbent will: Edit, revise, rewrite and review a wide range of reports, minutes, books, publications and other documents. Provide support and advise regional advisers on editing policies, principles, and procedures related to the preparation and dissemination of documents. Plan and supervise the work of the reports and documents units. Recommend works for publication and ensure their publication and distribution. Promote the translation and/or sale of WHO publications.

Tax-free salary including cost of living component currently not less than US\$31 340 plus attractive international allowances and social security benefits.

Applicants should have a university degree in biomedical science, or in English, journalism or a closely related subject. At national level, 5-10 years' editing, reviewing or publishing experience or a combination thereof; at international level, two years' experience of the same type, preferably in a developing country. Experience in an international organization desirable. Excellent knowledge of English.

Please send a detailed cv within three weeks of publication of this advertisement to:

**Personnel (MPR)
World Health Organization
CH-1211 Geneva 27**

quoting reference PUB/SEARO and this journal.

Only applicants under serious consideration will be contacted; they may be asked to sit an editorial test.

UNIVERSITY COLLEGE OF NORTH WALES Coleg Prifysgol Gogledd Cymru Bangor

**LECTURER IN DYNAMICAL
OCEANOGRAPHY IN THE
SCHOOL OF OCEAN SCIENCES**
Applications are invited for this post which will form part of the complement of the new School of Ocean Sciences to be established on 1 August, 1986 by the merging of the Departments of Physical Oceanography and Marine Biology. Applicants should have a higher degree in Physical Oceanography, or a closely related subject area, and it is desirable, though not essential, that their research interests should be in the physics of shelf seas and estuaries. Experience of numerical modelling techniques would be an advantage.

The School has a strong commitment to seagoing observational work and it is expected that the successful candidate would contribute to this aspect of the School's research and teaching activity. He/she would also be expected to participate actively in the inter-disciplinary programmes which are to be developed in the School of Ocean Sciences. The appointment will be on the University Lecturers' scale (£8050-£15 700 pa) depending on age and experience.

Applications (two copies) giving full details of age, qualifications and experience, together with the names and addresses of three referees should be sent by Monday, 16 June, 1986 to Mrs M. E. Macdonald, Assistant Registrar, University College of North Wales, Bangor, Gwynedd LL57 2DG, from whom further particulars can be obtained.

WEST LAMBETH HEALTH AUTHORITY

St Thomas' Hospital London SE1
ITU TECHNICIAN

To join the technical support team in the Intensive Care Unit.

The challenging work of this post involves preventative maintenance, disinfection and repair of the ventilators, used in the Unit, together with a range of patient monitoring equipment.

You will be expected to build up a close relationship with medical, nursing and other technician staff in the Unit. Participation in an on-call rota will also be required.

Ref: AU/JPB/16.

For application form and job description, please write to the Personnel Department or telephone our 24-hour answering service on 01-261 1185 quoting the appropriate job reference and title. Closing date will be 12 June, 1986.

An Equal Opportunities Employer.

UNIVERSITY OF CAMBRIDGE A RESEARCH TECHNICIAN

with a degree or HNC and several years' research experience to work on the isolation and characterisation of collagen genes from parasitic nematodes. Experience in recombinant DNA technology would be an advantage. Further information is available from Dr I. B. Kingston (0223 333333). The post is available for three years. Grade R7, Salary £6936-£8334. Applications, including a full cv and names of two professional referees, should be sent by 20 June, 1986 to: Dr I. B. Kingston, Moltano Institute, University of Cambridge, Downing Street, Cambridge CB2 3EE.

THE ROWETT RESEARCH INSTITUTE

Bucksburn, Aberdeen AB2 9SB
ENDOCRINOLOGIST
(HSO/SSO GRADE)

An endocrinologist is required to undertake research on the gastrointestinal and metabolic effects of gut hormones. The successful candidate will be expected to have a chemical, biochemical or physiological background with extensive experience of hormone assays and techniques for hormone purification and the development of assay methods. The endocrinologist will join a group of other endocrinologists engaged in research on appetite and its gastrointestinal control, seasonal cycles of reproductive and metabolic function and the effects of adrenal and sex hormones on the partition of energy between protein and fat deposition. Extensive collaboration with other scientists within the Institute is expected.

Qualifications: First or upper second class honours degree with at least two years relevant postgraduate experience for appointment at HSO and four years for SSO grade. Preferably to include a PhD in a biological science.

Salary Range: HSO £7788 to £10 541. SSO £9772 to £12 653 (under review). Non-contributory superannuation scheme.

The Institute is an Equal Opportunities Employer.

Applications together with a full cv and the names and addresses of two referees should be sent to the Secretary of the Institute. Tel 0224-712751.

Closing date: 19 June, 1986.



Department of
Oceanography

POSTDOCTORAL RESEARCH FELLOW

Applications are invited for the above post. The person appointed will be involved in the study of the dispersion of tracers by ocean gyres. The distribution of tracers provides a valuable source of information about not only the chemistry of the oceans but also the dynamics of the ocean circulation. The effect of CO₂ on climate is greatly influenced by its injection and subsequent mixing in the ocean. The aim of the project is to investigate the role of boundary currents and eddies in the dispersion of a passive tracer both within and between gyres. Dispersion processes will be studied using a numerical eddy resolving ocean circulation model. The dependency of the tracer field on the distribution of sources and sinks will be sought.

The post is on an NERC research grant and will run from 1st October 1986 for three years. Applicants should be recently qualified PhD's with experience in the numerical modelling of fluids. Some background in geophysical fluids would be advantageous.

Applications enclosing a cv and the names and addresses of two referees should be sent to Dr K. J. Richards, Department of Oceanography, The University, Southampton SO9 5NH. (tel: 0703 559122 Ext. 3317) from whom further particulars are available.

UNIVERSITY OF OXFORD

**Nuffield Department of Surgery
John Radcliffe Hospital
Headington, Oxford
OX3 9DU**

Applications are invited from suitably qualified and experienced persons to join a team researching into Pancreatic Islet Transplantation.

Both posts are based in the well equipped laboratories of the Nuffield Department of surgery.

Post 1

A qualified and experienced research assistant with experience in tissue culture and/or cryopreservation techniques, is needed to assist in the pancreatic islet cryopreservation project.

Post 2

A Biological Science Graduate is sought as a research assistant to work on techniques of pancreatic islet separation. Experience in laboratory techniques would be an advantage although full training will be given. Both posts are Grant supported and are subject to the Whitley Council conditions of service.

Salary range £5759-£7431.

Application with a complete cv and the names and addresses of two referees should be sent to the Administrator at the above address.

ELECTRONICS ENGINEERS

Help us to design and develop spacecraft!

We are among the world leaders in the field of communications spacecraft. In addition to other major projects we are prime contractors on the Inmarsat Maritime Communication Satellite programme. Current work involves collaborative projects covering the UK., Europe and the USA. Exciting jobs are available in the following areas of our Electronics Department:

Control Sub-systems Engineers

You will be responsible for the development of the system requirement and specifications and for the definition of interface documents and system hardware. Experience in control system design and trade studies is required.

Control Electronics System Engineers

You will be involved with the synthesis, analysis and development of high reliability aerospace hardware. Hands-on experience of hardware

developments involving the application of analogue and digital electronics in both signal and power handling circuits is required.

Software Engineers

To develop real-time software for spacecraft attitude control systems. You should have previous real-time experience using either high order languages or assembler.

All these positions require a degree or equivalent qualification in engineering, physics, mathematics or computer science and at least three years' relevant experience.

We can offer highly competitive salaries. Conditions of employment are those you would expect from a major company, and in appropriate circumstances, a generous relocation package is payable.

For an application form, please write to or telephone, Eric Eason, British Aerospace Plc., Space & Communications Division, FREEPOST, Argyle Way, Stevenage, Herts SG1 7BR. Telephone: Stevenage (0438) 736323 (24 hour answering service) or 736241.



BRITISH AEROSPACE

*...up where
we belong*



Department of Artificial Intelligence UNIVERSITY OF EDINBURGH

LECTURESHIPS IN ARTIFICIAL INTELLIGENCE

The Department of Artificial Intelligence is the leading European university centre for research into intelligent systems. Vacancies exist for two Lecturers, one in Intelligent Robotics and the other in Computational Linguistics.

INTELLIGENT ROBOTICS

The Department is participating in the Alvey large scale demonstrator project "Design to Product" to develop a computer-based mechanical engineering designer's assistant. In the longer run, the intention is to marry this work with on-going research into intelligent parts assembly by robot, currently funded by ACME, to achieve an integrated, highly automated system for designing, manufacturing, assembling and maintaining mechanical devices.

There are strong links with other departments, such as Mechanical and Electrical Engineering, particularly through a joint MSc programme in Information Technology, and a new joint honours degree in association with Computer Science.

COMPUTATIONAL LINGUISTICS

The Department works closely with the Centre for Cognitive Science to build models of human natural language processing; it is participating in the Alvey programme's natural language initiative by designing and constructing parser and dictionary tools, and it is collaborating with the Centre for Speech Technology Research to develop a system for recognising continuous speech.

In addition to a joint honours degree with Linguistics, the Department participates in an MSc course in Cognitive Science, in conjunction with Computer Science, Linguistics and Psychology.

Candidates should have postdoctoral experience, or equivalent experience, and proven ability for independent research and innovation. Besides making a contribution to the department's research, the candidate would be expected to participate in its teaching programme.

Salary will be on the lecturer scale, £8020-£15 700 pa, with superannuation under the Universities Superannuation Scheme. The starting salary will depend on age, qualifications and experience.

Further particulars may be obtained from:

The Personnel Office, 63 South Bridge, EDINBURGH EH1 1LS

quoting reference number 1601 (Robotics) or reference number 1602 (Linguistics). Applications (six copies) for either post, including cv and the names and addresses of three referees, should be sent to the same address not later than 20 June, 1986.

PLANT BREEDER— Coconuts

An experienced plant breeder is required by the Cocoa and Coconut Research Institute of Papua New Guinea to work at its centre near Rabaul. Responsible directly to the Principal Plant Breeder, the major area of research will be on coconuts with some research on cocoa.

Applicants should:

1. Hold a masters degree in science or agriculture with applied genetics;
2. Have a minimum of five years' practical experience in plant breeding;
3. Be self-motivated;
4. Preferably be single and aged between 25 to 35 years.

The contract is initially for three years (renewable) to commence as soon as possible.

Salary is negotiable subject to qualifications and experience and the contractual terms and conditions are attractive.

Early application should be made, with full cv and recent photograph to:

**Walter Judd Limited (Ref L742),
(Incorporated Practitioners in Advertising),
1a Bow Lane, London EC4M 9EJ.**

CITY OF LONDON POLYTECHNIC

Research Appointments

Applications are invited for the following research posts. All posts are tenable initially for two years and may be extended into a third year.

Research Fellowships

Candidates should normally have or expect to obtain soon a relevant PhD.

Research Fellows are currently paid on the scale £9,114 p.a. — £9,609 p.a. — £10,092 p.a. including London Allowance of £1,038 p.a. It is unlikely that successful candidates will be appointed to the third point of that scale.

Chemistry (ref 86/51)

Two posts for work on (a) the synthesis and pharmacological evaluation of amino-acid neurotransmitter mimetics; and (b) multi-element nmr studies of organo-metallic and co-ordination compounds using advanced techniques.

Physics (ref 86/52)

To investigate polymeric and colloidal materials using refractometric, turbidimetric and laser light scattering techniques.

Biological Sciences (ref 86/53)

To work on the identification of neurotransmitters in the auditory pathway of insects. Experience in electrophysiology and/or immunohistochemistry required.

Psychology (ref 86/54)

To investigate the involvement of short-term memory in children's reading and spelling.

Research Assistantships

Candidates should hold or expect to obtain a good honours degree in a relevant subject and be prepared to register for a higher degree with the CNA.

Research Assistants are currently paid on the scale £6,579 p.a. — £6,840 p.a. — £7,101 p.a. including London Allowance of £1,038 p.a. It is unlikely that successful candidates will be appointed to the third point of that scale.

Chemistry (ref 86/56)

Two posts for work on (a) the synthesis of photo-affinity probes for the GABA_B receptor; and (b) preparative and nmr studies of polydentate organophosphorus and related ligands and their complexes.

Geology (ref 86/57)

To investigate the sedimentology, sedimentary geochemistry and diagenesis of a Late Cretaceous stage boundary (Coniacian-Santonian) in the chalk of the Anglo-Paris basin.

Biological Sciences (ref 86/58)

Three posts available for research in:

- Regulation of myosin genes in mammalian muscle using recombinant DNA techniques.
- Study of the adsorption of microbial cells to metal surfaces, the subsequent formation of a biofilm and the effects of biocidal agents in this system.
- (i) Characterisation of ribosomal proteins involved in cycloheximide resistance and polymorphism in *Coprinus cinereus*.

OR

- To examine the mechanisms of action of the polypeptide "hormone" Somatostatin (Growth Hormone Release Inhibiting Factor).

Geography (ref 86/59)

To carry out research on the analysis and interpretation of the Middle Pleistocene deposits and palaeosols of north Suffolk and Norfolk.

Psychology (ref 86/60)

Three posts available for research in:

- Behavioural and neuropharmacological aspects of an animal model of depression.
- The relationship between sexual orientation and cerebral performance asymmetries.
- The development of mathematical concepts including probability in children.

For further details of any post, please telephone 01-283 1030, mention that you are interested in a research vacancy, and ask for the appropriate department.

To apply for any of the above posts, please write, providing full curriculum vitae and the names and addresses of two referees, to the Deputy Personnel Officer (Recruitment), City of London Polytechnic, 117 Houndsditch, London EC3A 7BU. Please quote the appropriate reference number and indicate the post you wish to apply for.

The closing date for applications will be 20th June 1986.

THE POLYTECHNIC IS AN EQUAL OPPORTUNITIES EMPLOYER
Applications from women, members of Ethnic Minorities and the disabled are therefore particularly welcome.

ANIMAL AND GRASSLAND RESEARCH INSTITUTE

POST 1 5/6/77

TEMPORARY HIGHER SCIENTIFIC OFFICER required for three years in the Ruminant Nutrition and Metabolism Department to work on a project to improve the prediction of voluntary intake by ruminants. This will involve the development of computer models of intake regulation in dairy and beef cattle.

Qualifications: Degree or equivalent in a biological/agricultural science with an emphasis on nutrition with a PhD or at least two years relevant post-qualifying experience. Knowledge of the use of computers in biology is desirable.

POST 2 1/6/73

SCIENTIFIC OFFICER / HIGHER SCIENTIFIC OFFICER required until March 1987 in the feed characterisation department of the Soil, Plant and Feed Chemistry Department to help develop methods for measuring degradation of proteins and the production of degradation products during ensilage. The work will involve the use of techniques such as Fast Protein Liquid Chromatography, Polyacrylamide Gel Electrophoresis and Amino Acid Analysis.

Other duties will include supervision of junior staff carrying out the routine analytical work of the feed characterisation laboratory.

Qualifications: Degree in chemistry or biochemistry. At least two years post-qualifying experience is required for appointment to the higher grade.

POST 3 3/1/72

SCIENTIFIC OFFICER required for one year initially in the Forage Plant Physiology Department to join a small team composed of three groups pioneering physiological studies of the interactions between soil, plant and animal in the growth and utilisation of grazed grass and grass-clover swards.

The appointee will join a small group in the Forage Plant Physiology Department which is directly involved in measuring the effects of grazing on the photosynthesis, respiration, gross production and turnover of plant material; the contribution of the plant material to the diet of the grazing animal; and the cycling of carbon and nitrogen in the soil and plant.

The field operations involve the operation of complex equipment as well as botanical measurements. There is a further requirement for data processing and computing.

Qualifications: Degree in biological sciences/agriculture or HNC with relevant practical experience. Experience of physiological and morphological measurements of grazed plant communities and a working knowledge of computing would be advantageous.

POST 4 1/1/87

SCIENTIFIC OFFICER required for three years in the Soil Plant and Feed Chemistry Department to carry out studies on near infra red diffuse reflectance spectroscopy to develop methods for the rapid chemical characterisation of forages.

Qualifications: Degree in chemistry with training in statistics or mathematics or a degree in mathematics. Experience in spectroscopy an advantage.

Applications invited from existing graduates and those expecting to graduate in 1986. Registration for higher degree available for suitable candidates.

Starting Salary (under review):

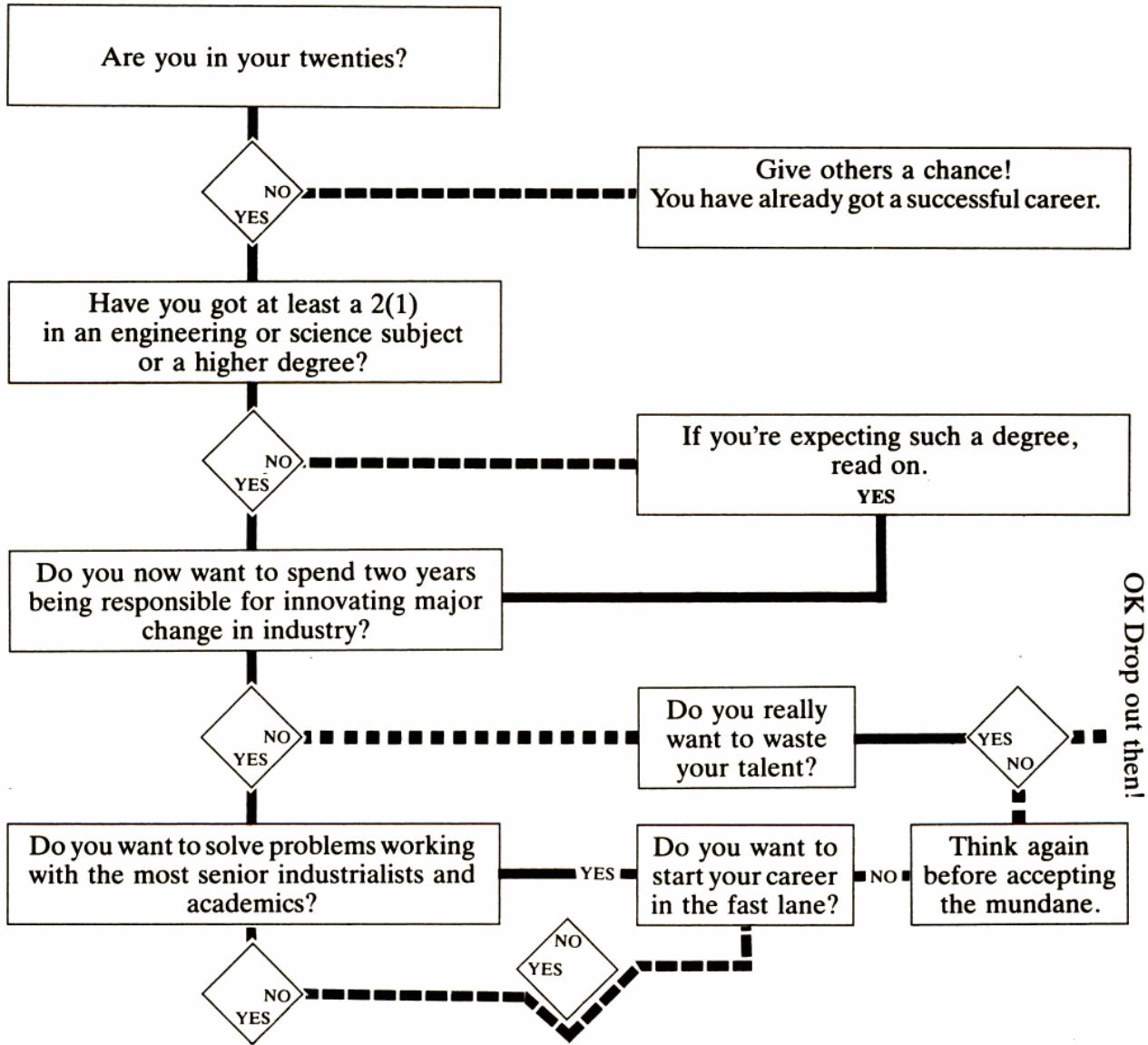
Scientific Officer £6190-£6878
rising to £8561

Higher Scientific Officer £7788-£8618
rising to £10541

Applications with curriculum vitae and three referees to the Personnel Officer, Animal and Grassland Research Institute, Hurley, Maidenhead, Berks SL6 5LR by Friday 13 June, 1986 stating post applied for.

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Now you've got this far, you could become a Teaching Company Associate. A rare opportunity to participate in an active partnership between universities/polytechnics and industry. A chance to develop novel solutions to today's industrial problems.

To find out more about the Teaching Company Scheme and the specific Programmes available fill in the coupon or phone:

Martin Rees, Teaching Company Directorate, SERC, North Star Avenue, Swindon, Wilts. SN2 1ET.
Tel: (0793) 26222 Ext. 2335.

NAME _____

ADDRESS _____

POSTCODE _____

TEL: (Home) _____

(Work) _____

Computer Board and Research Councils Joint Network Team and Network Executive

The UK Academic Community has more complete and better developed networking facilities than any other comparable academic group in the world. They result from the integration of local and wide area data communication, based on the principles of Open Systems Interconnection (OSI). The work arises from a joint initiative to support networking by the Computer Board and the Science and Engineering Research Council.

The Joint Network Team carries out a programme of coordination and development to enhance and expand the available networking facilities. Activities include the introduction of newly developed International Standards for OSI and team members are expected to acquire familiarity with current networking developments.

The Network Executive controls the operation and expansion of the national packet network used by the academic community, and is currently planning network upgrades to exploit megabit links.

Applications are invited for a senior post, up to Grade 7, in the Joint Network Team. The duties will include promotion of networking developments, liaison with universities on networking matters and direct involvement in the specification of University Network and Computer Systems.

Applications are also invited at the Senior Scientific Officer level for the post of Network User Support Manager in the Network Executive, to coordinate university liaison and the provision of user information and advice.

Candidates should have a first or second class honours degree in a scientific subject with at least 4 years appropriate post-graduate experience and a sound basic knowledge of computing and telecommunication technologies. They should be familiar with the management of technical projects. Experience of computing and communication in a university environment would be an advantage.

Salaries would depend on age, experience and qualifications and will be in one of the ranges:

Grade 7 (Principal Scientific Officer) £13508-£18363
Senior Scientific Officer £9772-£12653

The posts are based at the Rutherford Appleton Laboratory in Oxfordshire, but involve some travel.

They may be filled by permanent employment with SERC or by secondment from a University or from Industry for a fixed period. Some assistance with expenses incurred in house sale/purchase may be available. In certain circumstances employees may be permitted to undertake a limited amount of private professional consultancy work.

Contact Recruitment Office, Personnel Group, Rutherford Appleton Laboratory, Science and Engineering Research Council, Chilton, Didcot, Oxon OX11 0QX. Tel: (0235) 445435, quoting reference VN463.

Closing date for applications: 20th June 1986



Rutherford Appleton Laboratory

THE UNIVERSITY OF NEWCASTLE

New South Wales, Australia
**PROFESSIONAL OFFICER—
ELECTRON MICROSCOPE
UNIT**
(Position No. N62/86)

The Unit is a University facility housed in the Medical Sciences Building, and the equipment comprises a JEOL-100CX Transmission Electron Microscope, a JSM-840 Scanning Electron Microscope fitted with a Tracor-Northern 5500 EDS system, and an older JXA-50A SEM/Probe now mainly used for WDS applications.

The successful applicant would preferably be a physical scientist, and will primarily be responsible for the operation and development of the two SEM systems, and should therefore have some experience and knowledge of computing (including Flextran), Electron Probe Microanalysis and with SEM operation generally. Development of silicate, oxide, sulphide and phosphate analytical and correcting procedures is envisaged.

Appointment will be made at the level of Professional Officer Grade 1-2 (salary range: \$A19 784-\$30 540 pa) depending upon qualifications and experience. Technical information can be obtained by contacting the acting Academic Head of the Electron Microscope Unit: Prof E. O. Hall, Department of Chemical and Materials Engineering, University of Newcastle, Shortland, N.S.W. 2308, Australia.

Excellent conditions of employment apply. Superannuation may be available after a qualifying period.

Applications, quoting position number, should be addressed to the Staff Officer, the University of Newcastle, N.S.W. 2308, Australia. Please include full information regarding qualifications, experience, previous employment, state of health and any other relevant information. Applicants should also state the names and addresses of three referees or supply copies of recent references. Reasonable travelling and relocation expenses will be met by the University.

Applications close 27 June, 1986.

Equality of Employment Opportunity is University Policy.

UNIVERSITY OF NOTTINGHAM Department of Theoretical Mechanics

Nonlinear elastic and Piezo-Electric Surface Waves

Applications are invited for a
**POSTDOCTORAL RESEARCH
ASSISTANTSHIP**

to extend recent work on nonlinear effects on elastic surface waves to analysis and computation for piezo-electric and other materials having applications in surface acoustic wave devices. Applied mathematicians with (or about to complete) a PhD in any field involving nonlinear waves would be most suitable for this post. The programme includes collaboration with research workers in Britain and in Paris.

The appointment (funded by SERC) is for two years, available from 1 June, 1986. Initial salary on scale £8020-£8505 pa. (under review). Please write or telephone Dr D. F. Parker, Department of Theoretical Mechanics, University of Nottingham, Nottingham NG7 2RD. Tel 0602 506101, Ext 2146. Applications including a cv and naming two referees should be received by 10 June, 1986.

UNIVERSITY OF OXFORD Nuffield Dept of Clinical Medicine

RESEARCH TECHNICIAN

Applications are invited for a Research Technician to join a group working on the characterization of lymphoid tumours, by DNA analysis. The work involves extraction of DNA from lymphoid tumours, restriction enzyme digestion of DNA, Southern blotting and the analysis of the pattern or rearrangements of the immunoglobulin and T-cell receptor genes. The post is funded for two years by the Cancer Research Campaign. Salary on the Whitley Council MISO Scale (£6008-£7249) depending on age and experience. Minimum qualifications: HNC or degree in related subject.

Applications in writing requesting an application form and job description from:

Departmental Administrator
Nuffield Dept of Clinical Medicine
Room 5801

John Radcliffe Hospital
Headington
Oxford OX3 9DU

Closing date for applications:
Friday 13 June, 1986.

The Agricultural Research Council of Norway

Institute of Aquaculture Research (AKVAFORSK)

AKVAFORSK carries out research in fish farming with special emphasis on quantitative genetics/selection, nutrition and fish health. AKVAFORSK has two large, well equipped research stations on the coast south of Trondheim, at Averøy, and Sunndalsøra. Some of the scientists are working at the Agricultural University of Norway As, in close cooperation with the Department of Animal Genetics and Breeding and the Department of Poultry and Fur Animals.

At AKVAFORSK there is a vacancy for a researcher in quantitative genetics. Applicants should have a PhD degree or equivalent qualifications. Experience in research in aquaculture is an advantage but not a request.

Salary of Nkr. 141.209-191.678 according to earlier experience and qualifications. Applications should include a cv and the names of two referees and should be sent to Institute of Aquaculture Research, Box 10, 1432 As-NLH, Norway.
Closing date: 1 July, 1986.

SCIENTISTS: PROMOTE YOURSELF!

Why not utilise your training and experience as a medical/technical representative where career prospects are related to your own efforts?

Opportunities for trainees arise regularly throughout the UK and offer excellent salaries + car + benefits. Phone or write (no stamp needed) for our free information booklet:

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Talentmark

Recruitment Consultants
Freepost, London W2 1BR.

pdo

"Sounds Exciting"

Development Engineers for Optical Media

Salary Range £8,500-£11,000

Philips Du Pont Optical, the world's largest manufacturer of optical media discs with production facilities in Germany, France, Italy, U.S.A. and the U.K., are currently planning to extend their existing optical disc activity at Blackburn with a £4 million investment in a new Compact Disc manufacturing centre. **If you are a young graduate looking for your first career move, this is an opportunity to join in an area of exciting new technologies for a highly successful product.**

You'll join a multi-disciplinary team responsible for innovation and improvement of disc manufacturing processes. Your previous experience will include development work or problem solving within a process environment. Engineers are now required in the following three areas:-

Thin Film Development

You will be a Chemistry graduate and work on the development of thin film metalisation processes required to provide the reflective surface for optical discs. Ref D3

Materials & Processes Development

You will have a degree in Materials Science or Metallurgy and be involved in the development of materials and processes

used in the replication of the various optical disc formats. Previous experience in plastic moulding techniques would be an advantage. Ref D2

Coating Development

You will be involved in the development and improvement of processes for the application of protective coatings, adhesives and decorative finishes. A degree in Chemistry or Polymer Chemistry is required. Ref D1

All posts offer first class career prospects for people looking for that vital first career move and involvement in a product with an exciting future.

As well as an attractive salary we offer the benefits package expected of a large company, together with relocation expenses where appropriate. This pleasant part of North East Lancashire is within very easy reach of the Yorkshire Dales, Lake District and Fylde Coast, and house prices are below the national average.

Please phone Brian Haworth on Blackburn (0254) 55241 Ext. 396 or send your C.V. to him at Personnel Department, Philips and Du Pont Optical, Philips Road, Blackburn BB1 5RZ quoting the appropriate reference.

"Exciting Sounds"

Philips and Du Pont Optical

Molecular Biologists

France

Located 6 miles south of Toulouse, Sanofi Elf Bio Recherches, a subsidiary of the French oil company, Elf Aquitaine, is a major French biotechnology company involved particularly in the pharmaceutical, seed and food industries.

Growth has created opportunities for Molecular Biologists to join a group working on plant genetic engineering within the Phytotechnology Department, and construct chimeric genes for transfer and expression of foreign genes in plant cells.

With a PhD in Biology, you must have experience in expressing foreign genes in eukaryotic cells, be flexible and able to manage your own project area. A broad background in plant science would be an advantage.

Salary will be dependent upon qualifications and experience. Relocation assistance will be provided.

Please write enclosing your cv to M fabre, Ref: B/T 2024/S.

PA

71 bis Allées Jean-Jaurès, 31000 Toulouse, France.
Tel: Toulouse 63.70.63.

LIBRARY ASSISTANT

A temporary post offering one year's post-graduate work experience.

Wyeth Research (UK) has a busy scientific library which serves the needs of the Company's research, medical and other staff.

The post which will become vacant in mid-August, will be of interest to graduates wishing to gain some relevant work experience prior to taking up an MSc course in library/information studies.

The duties will include dealing with the receipt and circulation of journals, answering queries from library users, and general clerical duties relating to the maintenance of the library and its services. There will be an opportunity for considerable contact with library users.

A degree in a scientific discipline is preferred, and the ability to type would be an advantage.

We are offering a competitive salary, and a benefits package which includes an excellent subsidised staff restaurant and an active sports and social club.

To apply, please submit a succinct but comprehensive curriculum vitae, or apply for an application form to:

**Personnel Department, Wyeth Laboratories,
Huntercombe Lane South, Taplow,
Nr. Maidenhead, Berkshire SL6 0PH
Tel: Burnham (06286) 4377 (Ext 4342). Ref: SI/2**



Wyeth Laboratories

Sensory Panel Co-ordinator

Assessing the potential of own-label products Salary negotiable

Tesco has a strong commitment to maintaining high quality standards across its 2,500 strong own-label range. In furthering our innovative product development programme, a sophisticated assessment system is therefore vital.

Working as a key member of the Technical Services Department, your responsibilities as Co-ordinator will be wide ranging. They will involve the design and introduction of a sensory evaluation facility, calling for the recruitment and training of 4 teams of external panelists; planning schedules and test procedures to meet new product development and quality assurance requirements; and the processing and issuing of clear and accurate reports. Close liaison with marketing, buying and technical teams is fundamental.

You will need to combine a food science degree or equivalent and specialisation in sensory analysis with at least 3 years' experience in a similar

or related environment, ideally including some knowledge of meat. Experience of creating and maintaining a computer database is essential.

The salary offered will reflect your qualifications and experience. Benefits are in line with large company practice and include relocation expenses where appropriate.

Please send a full cv, including current salary, to Judith White, Personnel Officer, Tesco Stores, Tesco House, Delamare Road, Cheshunt, Hertfordshire EN8 9SL.

Tesco is an equal opportunity employer.



Department of Biological Sciences

Research Technician— Microbiology Immunology

£6234-£8697

Required to work on a project funded by the NAB Biotechnology Initiative, the successful applicant will join a team investigating the development of vaccines for use in aquaculture, and also to assist in the development of modern techniques and testing programmes. Applicants should possess, or expect to obtain this year, a good honours degree in Biological Sciences, with interests or experience in microbiology, immunology or molecular biology.

Starting salary will be dependent on age, qualifications and experience. The appointment will be for one year in the first instance, with probable extension for a further two years (fixed term contract).

Application forms—to be returned by Friday 20 June, 1986—and further details are available from the Personnel Department, Plymouth Polytechnic; Tel (0752) 264639.



**Plymouth
Polytechnic**

Drake Circus, Plymouth
Devon PL4 8AA



**Southampton
THE
UNIVERSITY**

Research opportunities in Microelectronics Research Assistant

A very versatile and able person is needed in the Microelectronics Group of the Electronics Department for research into the Reactive Ion Etching of Silicon Dioxide and other materials for an Alvey contract. The successful applicant will be required to work with minimum supervision within a highly motivated team, and to liaise with other establishments engaged on this project.

An Honours First Degree in Electronics, Material Sciences, Chemistry or similar is essential.

Salary in the range £7000 to £11500 depending on relevant experience.

S.E.R.C. CASE studentships

Ph.D. Projects in the novel areas of Sub micron fabrication, Rapid Thermal Annealing and Micro Sensors exist for applicants having First or 2.1 Honours degrees in Electronics, Physics or related subjects.

Applications (2 copies) with details of date of birth, qualifications, experience and names of two referees to Mr D. A. S. Copland, Staffing Department, University of Southampton, Highfield, Southampton, SO9 5NH, quoting reference number 2279.

CLARENDON LABORATORY AND MATHEMATICAL INSTITUTE

Oxford University SENIOR RESEARCH ASSISTANTSHIP FOR NONLINEAR SYSTEMS PROJECT

Applications are invited for the post of Senior Research Assistant (RSII) to collaborate with Prof T. B. Benjamin, FRS, of the Mathematical Institute and Dr T. Mullin of the Clarendon Laboratory on an inter-disciplinary research project concerning Nonlinear Systems. This project, for which extensive support is expected from the SERC, will amplify an established programme combining experimental and mathematical studies of fundamental nonlinear phenomena, largely but not exclusively in fluid dynamics.

The post will carry responsibilities for design and research applications of interfacing between experimental systems and computers (such as MICROVAX 2). It is expected that a major contribution will be made to the development of advanced software and hardware for novel methods of signal processing.

Applicants should have suitable qualifications in Physics or Engineering, preferably with proven experience in the area of real-time data analysis and with a general interest in modern ideas about Chaos in Dynamical Systems. The appointment will be for four years from 1 October, 1986, with salary, according to age and qualifications, in the range £11790 to £15700.

Applications, including full cv and names of at least two referees, should be sent not later than 6 June to Prof T. B. Benjamin, Mathematical Institute, 24/29 St Giles, Oxford OX1 3LB.

UNIVERSITY OF NEWCASTLE UPON TYNE Department of Civil Engineering NERC Water Resource Systems Research Unit

HYDROCHEMICAL MODELLER
Applications are invited from candidates for the above post, to be appointed at the level of Research Associate or Senior Research Associate, in the NERC Water Resource Systems Research Unit. This Unit is concerned with the fundamental development of mathematical models of the transport of pollutants and sediment within river basins and with the practical application of such models in the management and protection of water resources. Particular emphasis is being placed on the ground-water phase of the hydrological cycle. The Unit's research is therefore expected to be increasingly relevant in the light of such developing problems as waste disposal, acid rain, deforestation and pollution from agriculture. The post holder will play a vital role in a multi-disciplinary research programme, which will involve collaboration with the Institute of Hydrology at Wallingford, and he/she will also have the chance to influence the direction of research within the Unit.

Applicants are expected to have expertise in hydrochemistry and an interest in the development of numerical models describing reactive mass transport in subsurface environments for pollutants such as nitrates and landfill leachates. A background knowledge of hydrology of hydraulics would be an advantage.

The level of appointment will depend on the qualifications and research experience of the successful applicant. Starting salary for a Senior Research Associate is up to £13290 pa on the Range II scale (£11790-£15700) and for a Research Associate is up to £9495 pa on the Range 1A scale (£8020-£12780) according to qualifications and experience. The post is available forthwith and is tenable for three years.

Applications (three copies) with the names and addresses of three referees should be sent not later than 13 June, 1986, to Professor P. E. O'Connell, Department of Civil Engineering, The University, Newcastle upon Tyne NE1 7RU.

EXPERIMENTAL SCIENTIST

Our discharge lamp research group is expanding its range of activities and we are looking for an experimental scientist for research on gas discharge devices with applications to displays and lighting. The work is likely to appeal to an experimental physicist with an interest in optical, spectroscopic and electrical measurements. It will involve investigations of gas discharges under a variety of conditions with a view to their basic properties and behaviour. An interest in the application of electronics to measurement and control is likely to be needed.

Our group has a strong reputation in this field. We would therefore hope to attract a good graduate in physics (or a related subject) to work in a stimulating environment on some interesting experimental physics.

Please write for further details and an application form to: Head of Discharge Lamp Research, THORN EMI Lighting Limited, Research & Engineering Division, Merton Road, Leicester LE4 7PD.

**THORN EMI
Lighting**

UNIVERSITY COLLEGE LONDON

Research in Plant Biochemistry
and Microbiology

Applications are invited for postdoctoral and postgraduate positions:

Photosynthesis
Research Group

Postdoctoral research assistant 1A (with Professor M. C. W. Evans). The project involves the isolation and characterization of photosystem 2 preparations from plants and algae, and spectroscopic studies of redox carriers in the reaction centre. Applicants should have experience in biochemistry/biophysics and an interest in membrane systems, energetics or spectroscopic techniques. (SERC funded for three years, salary £9317-£10 297).

Postgraduate research assistant 1B (with Dr J. H. A. Nugent). Investigation of photosynthetic water oxidation in higher plants, cyanobacteria and algae. Suitable candidates may be able to register for a PhD (SERC funded for two years, salary £8352-£9317).

Plant Stress
Metabolism Group

Postdoctoral research assistant 1A (with Professor G. R. Stewart). Metabolic and enzymological studies of ammonia assimilation in mycorrhizas. Experience of one of the following areas desirable: gas chromatography-mass spectrometry, enzyme purification, immuno-histochemistry. (SERC funded for three years, salary £9317-£10 297).

Research Studentships

SERC-CASE (Dr Hilary Richards, with Professor D. Hopwood, John Innes Institute) to investigate the mechanism of plasmid transfer and improvement of plasmid vectors for *Streptomyces*.

NERC (Dr R. J. Rowbury). Factors influencing survival of plasmid bearing organisms in estuarine and marine environments.

NERC (Professor G. R. Stewart). Nitrogen acquisition and assimilation in aquatic angiosperms.

AERC (Quota award). Available in the areas of biophysics/biochemistry, molecular/cellular studies and ecophysiology.

Applications for any of the above posts, together with the names and addresses of two referees, should be sent to the Department of Botany and Microbiology, University College London, Gower Street, London WC1E 6BT.

Head of Regulation and
Monitoring

£30,000 +

READING

Thames Water is responsible for the management of the water cycle over 5,000 square miles including London and serves 11m customers. It has a turnover of £500m and employs 9,000 people. Having recently established a new top management structure in preparation for privatisation, the Authority is now seeking to fill the key role of Head of Regulation and Monitoring.

Reporting directly to the Chairman, this position is responsible for forecasting and planning the natural resources of the Thames catchment together with management and control of the scientific and technical content of licences, consents and standards throughout the area.

The position also provides a continuous independent review of water and environmental quality and the monitoring of customer and community service. In this

role, the Head of Regulation and Monitoring may act as the Authority's spokesman on matters of local or national importance in the field of supply, pollution and the environment.

Candidates should display a thorough grasp of the technologies involved in the water industry and have the stature to command respect from Authority staff and the wider public as the independent guardian of standards and service.

Excellent conditions of service include a good salary, quality car, BUPA and relocation expenses if required.

KHM Associates have been retained to help fill this important position and candidates should write with full details to David J. Clarke, KHM Associates, 1 New Bond St., London W1Y 9PE. Tel: 01-828 1114



RUNNING WATER FOR YOU

Analytical
Technicians

Have you sound experience in the operating of HPLC equipment for chromatographic analysis?

We are looking for a young Technician (male or female) who can use this equipment *confidently*, is familiar with other analytical techniques and who is studying for, or has obtained, a HTEC in Chemistry.

At Fosroc we use such equipment to analyse building materials containing polymeric, organic and inorganic chemicals. Experience in testing building materials would therefore be an added advantage.

We pay competitive salaries, relocation expenses if appropriate, and work in smart purpose-built Laboratories in Birmingham.

If you would like to join our lively young team, and meet these qualifications please send a full C.V., giving details of your experience to date, current salary and daytime telephone number, to Miss Jane Ranson, Fosroc International Limited, 285 Long Acre, Nechells, Birmingham B7 5JR.



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Leicestershire

CHIEF EXECUTIVE AND COUNTY CLERK'S DEPARTMENT

County Emergency Planning Section

EMERGENCY
PLANNING OFFICERS

Scale S02 Salary £10,950 — £11,604 p.a.

Two mature and energetic officers are required to assume principal responsibility for training local authority officers and volunteers in civil defence duties. They will also be required to participate in other emergency planning activities related to peacetime and wartime emergencies. Duties will include the preparation of training material, lecturing and close liaison with the staffs of County and District Councils and with local communities.

Candidates should be educated to degree standard, possess good organisational ability and have experience in training methods and equipment. They must be able to communicate effectively in writing and speech, and be capable of working on their own initiative. Previous experience in central or local government, particularly in emergency planning, would be advantageous, as would a knowledge of communications systems. Some evening and weekend work is involved.

Successful candidates would be expected to live in Leicestershire and possess a current car drivers licence.

It is intended to hold interviews in the third week in July.

Casual car mileage allowance is payable. Removal and relocation expenses are payable in approved cases.

Informal enquiries to Mr. S. W. Bainbridge, County Emergency Planning Officer, ext. 7405.

Further details and application forms (returnable by 13th June) obtainable from the Personnel Section, Chief Executive and County Clerk's Department, County Hall, Glenfield, Leicester. Tel: (0533) 871313, ext. 7433.

EQUAL OPPORTUNITIES POLICY: Applications are welcome from people regardless of their race, ethnic origin, religion, sex, marital status or disability: disabled applicants will be guaranteed an interview if suitably qualified and/or experienced, and supported by a recognised agency e.g. a D.R.O.

Toxicologist

Sterling-Winthrop Research Centre

Continued expansion in our Toxicology department means that we now require a person within the General Toxicology section who is seeking progression as a Toxicologist/Study Supervisor.

In this position, reporting directly to the Section Head, you will be expected to plan, manage, and report a number of toxicity/carcinogenicity studies primarily in rodents, to a standard acceptable to international government regulatory agencies.

Applicants should be graduates in Physiology, Pharmacology, Biochemistry or Toxicology with 2-4 years relevant industrial experience. An interest or experience in statistics, computing and animal husbandry would be an advantage.

Our Research Centre is part of Sterling Research Group which is responsible for the worldwide research and development programme for Sterling Drug Inc., a major international pharmaceutical company with a wide range of both ethical and proprietary medicines. The Centre is located in an attractive rural parkland setting at Alnwick, Northumberland, within easy reach of Newcastle and Edinburgh. A competitive salary is offered as well as the additional benefits appropriate to a major company.

To apply, please send a curriculum vitae or write for an application form to:

The Personnel Controller,
Sterling Research Group - Europe,
Sterling-Winthrop Research Centre,
Alnwick,
Northumberland NE66 2JH
Telephone: Alnwick (0665) 604141.

Sterling Winthrop
Research & Development

UNIVERSITY OF OXFORD DEPARTMENT OF BIOCHEMISTRY OXFORD OLIGOSACCHARIDE GROUP

POSTDOCTORAL RESEARCH ASSISTANT-1A

Ref: BC/153

A vacancy exists for a Postdoctoral Assistant to work on the solution conformation of oligosaccharides using NMR techniques. Excellent NMR and computing facilities are available including 500 Hz machines and microvaxes. Expertise in modern (2D) high resolution methods is essential.

The post is available for three years only in the first instance.

Salary on the scale £8020-£12 780 pa depending upon age and qualifications.

Applications, including the names and addresses of three referees should be sent by 20 June, 1986, to:

The Administrator,
Department of Biochemistry,
University of Oxford,
South Parks Road,
Oxford OX1 3QU.

THE QUEEN'S UNIVERSITY OF BELFAST

A co-operative grant has been awarded by the Department of Trade and Industry to the Department of Chemical Engineering and Short Brothers, PLC, to develop methods of evaluation of polymer composite used in the aerospace industry. This is a new and exciting area of polymer technology and will provide the successful candidates with opportunities to gain valuable first-hand experience of this rapidly developing high technology industry. Applications are invited for the following:

ASSOCIATE

Candidates, UK citizens, must be under 28 years of age, holding a good Honours degree in Chemistry, Chemical Technology or Chemical Engineering. At least one year's experience in a manufacturing or processing industry desirable.

A competitive salary will be paid. The Associate will be employed by the University for two years with the majority of the work carried out at Short Brothers PLC.

SENIOR ASSOCIATE

Applicants should preferably be post-graduates, preferably in Polymer Science or Technology. The Senior Associate will be responsible, for a period of three years, for teaching duties in the Department of Chemical Engineering and contribution to the Teaching Company programme.

A competitive salary will be paid. This programme is supported by the Science and Engineering Research Council, the Department of Trade and Industry under the Teaching Company Scheme. Informal enquiries about either position may be made to Professor P. L. Spedding at Belfast (0232) 661111, Ext 4250. Applicants should submit a full cv and the names and addresses of three referees to the Personnel Officer, The Queen's University of Belfast BT7 1NN, Northern Ireland, from whom further particulars are available.

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Applicants should have a degree and, for more senior posts, relevant experience. Further details and Application Forms, to be returned within three weeks after appearance of this advertisement, are available from Staffing Officer, Kingston Polytechnic, Penrhyn Road, Kingston KT1 2EE (01-549 1366) Ext 505.

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Sub-regional Department of
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Radiation Protection Service—
St Luke's Hospital, Guildford
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TECHNICIAN III/IV OR II

A Medical Physics Technician is required to join the team providing a comprehensive radiation protection and diagnostic X-ray physics service to the seven Health Authorities in the southern half of the Region. The person appointed will be based in the South West Surrey Health Authority at St Luke's Hospital, Guildford and although he/she will be involved in all aspects of the work, radiation protection and quality assurance surveys of diagnostic radiology will comprise a major responsibility.

Minimum qualifications are OTEC, HTEC or equivalent, plus three years relevant experience for Grade III. Persons with less experience will be considered for Grade IV whereas technicians already having two years experience at Grade III may be appointed at Grade II. A current driving licence and the use of a car are essential.

Salary Scale Grade II £8073-£10 070; III £8703-£8664; IV £5653-£7431 (plus £149 fringe allowance)

For further information contact Mr M. L. Ramsdale, Principal Physicist on Guildford 571122, Ext 487.

Application forms and a job description are available from the Personnel Manager at St Luke's Hospital, Guildford GU1 3NT, Tel 60182.

SOUTH GLAMORGAN HEALTH AUTHORITY

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Service—Wales

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(COMPUTING)

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Informal enquiries to Dr A. Beal.

Application forms and job description available from the :- Assistant Administrator, Welsh Regional Transfusion Centre, Rhydylafar, St. Fagans, Cardiff CF5 6XF.

Closing date: 26 July, 1986.

CAVENDISH LABORATORY University of Cambridge RESEARCH SCIENTIST— POLYMERS

A three-year position is available from October for a postdoctoral scientist to work on a project funded by ICI plc under their Joint Research Scheme on Molecular Aspects of Macroscopic Deformation in Glassy Polymers. The project will involve the techniques of mechanical testing and microscopy (electron and optical).

Candidates should have, or expect to receive shortly, a PhD in Physics, Chemistry or Materials Science. Salary on a scale from £8020 to £9495 pa.

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OCCUPATIONAL HYGIENIST

A new charitable foundation has been established to promote and provide occupational health and safety services to the maritime and related industries, this includes ship-building, ship-repair, heavy and light fabrication and engineering including the offshore industry. It currently provides a service to British Shipbuilders and its subsidiaries from multi-disciplinary occupational health centres based in the North East of England on Tyneside and in Scotland on Clydeside.

Applications are invited from suitably qualified and experienced persons to fill the post of Occupational Hygienist, based on Clydeside. Formal training in occupational hygiene is a requirement, and

candidates should ideally be an Associate Member of the Institute of Occupational Hygienists or a holder of the Certificate of Operational Competence in Occupational Hygiene. Consideration will also be given to recent occupational hygiene graduates or science graduates with occupational hygiene experience. The successful candidate will have a high degree of self motivation, and be able to work with minimum supervision. Salary is negotiable but will be commensurate with qualifications and experience.

Applications with full curriculum vitae should be sent to the Chief Occupational Hygienist, Mr T. G. E. Gillanders

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Degree or equivalent required plus experience in conservation. Knowledge of planning system an advantage. Must be personable and able to write clearly.

Two year contract at a fixed salary of £8500. Funded by Nature Conservancy Council, World Wildlife Fund and local councils.

For details and application form send SAE to: Avon Wildlife Trust, The Old Police Station, 32 Jacobs Wells Road, Bristol BS8 1DR. Closing date 12 June, 1986.

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FOR FURTHER DETAILS AND AN APPLICATION FORM (TO BE RETURNED BY 20 JUNE 1986) WRITE TO CIVIL SERVICE COMMISSION, ALCON LINK, BASINGSTOKE, HANTS RG21 1JB, OR TELEPHONE BASINGSTOKE (0256) 468551 (ANSWERING SERVICE OPERATES OUTSIDE OFFICE HOURS). PLEASE QUOTE REF: T/6894.

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DEPARTMENT OF TRADE & INDUSTRY

UNIVERSITY OF SURREY Department of Biochemistry RESEARCH OFFICER— MECHANISMS OF TASTE CHEMORECEPTION

Applications are invited for a post of Research Officer funded by the AFRC for three years and available immediately in the Department of Biochemistry at the University of Surrey. Applicants should have a good honours degree in biochemistry, chemistry, pharmacology or an appropriate applied science and be willing to apply their expertise to a challenging project concerned with the mechanisms of taste chemoreception with particular reference to compounds capable of eliciting more than one primary taste. Experience of ligand binding studies and/or preparative HPLC and/or sensory panel studies could be advantage. The project will be jointly supervised by Dr M. N. Clifford (Department of Biochemistry, University of Surrey) and Dr G. G. Birch (Department of Food Technology, University of Reading). Work will commence at the University of Surrey but will transfer to the University of Reading after about 18 months. There will also be contact with Dr G. C. Brownsey at the AFRC Food Research Institute, Norwich. Further details of the post may be obtained from Dr Clifford on 0483 571281 Ext 2506 or Dr Birch on 0734 875123 Ext 7379. Salary will be on the incremental Research & Analogous Scale IB (up to £9495 pa) at a point depending on age, qualifications and experience.

Applications in the form of a cv (three copies) and including the names and addresses of two referees should be sent to the Personnel Office (JLG), University of Surrey, Guildford, Surrey GU2 5XH by 13 June, 1986 quoting Ref 519.

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Please apply with a comprehensive CV to Pamela Hill, Personnel Officer, Regional Services & Administration, Warner Lambert (UK) Ltd, Chestnut Avenue, Eastleigh, Hants SO5 3ZQ.

The closing date for applications is four weeks after ad.

WARNER LAMBERT

KINGSTON POLYTECHNIC

FACULTY OF SCIENCE

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One of the Technicians will work in the electronics teaching laboratory and the other in the Life Service Centre. Both of these posts will be required to work mainly unsupervised in busy laboratories. Duties will include repairs and maintenance of equipment and there will be some involvement in project and research work.

The salaries for these positions are as follows: Senior Technician, Scale 4/5 = (£7593-£9390 pa); Technicians, Scale 3 = £6927-£7449 pa. All figures include a London Allowance.

Further details and an application form are available from the Personnel Office, Kingston upon Thames, Surrey KT1 2EE. Tel 549-1366 Ext 505.

Closing date for receipt of applications 20 June, 1986.

UNIVERSITY OF MANCHESTER

Department of Rheumatology

RESEARCH TECHNICIAN

required for a three-year project on immunity to collagen in arthritis. The work will primarily involve biochemical and immunosay techniques. Candidates must have at least ONC or equivalent, and applications from graduates welcome, initial salary £5683 pa (under review). Please send CV and names and addresses of two referees to Dr K. Morgan, Department of Rheumatology, University of Manchester Medical School, Oxford Road, Manchester M13 9PT.

LOCH RANZA CENTRE

Isle of Arran Scotland

A temporary Field Tutor post is to be filled through to October. It would be suitable for a newly qualified honours graduate in Biology or Biology combined with Geography. Full training will be provided.

An interest in Marine Biology would be necessary.

Applications with CV and two referees should be sent to the Centre Director, Dr Hugh McKerrill, address above.

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Lectureships in Computer Science and Information Engineering

Major developments in the areas of Computer Science and Information Engineering are taking place within the University with very substantial support from the UGC and from the Engineering and Technology Programme. Existing activities are being brought together in a new Department of Information Engineering, Electronics and Computer Science in the Faculty of Engineering and Applied Science, which will offer two new degree courses in addition to existing courses: a 3 year BSc in Computer Science and a 4 year BEng in Integrated Information Engineering.

Applications are invited for a number of LECTURESHIPS to support this expansion. The successful applicants will be expected to participate fully in the teaching programme of the department, and to conduct research in an area of Computer Science or Information Engineering. Candidates should have a degree in Engineering, Computer Science, Science or Mathematics, and a higher degree and/or industrial experience in a relevant area within the scope of the department. Appointments as TEACHING FELLOWS may be offered to appropriately qualified candidates. The successful candidates will take up their appointments as soon as possible.

Salary for Lecturers is on the scale £8020-£15700 pa (under review). Salary for Teaching Fellows is on the scale £8020-£12 780 pa (under review). Further particulars are available from Mr D. W. Powell, Staffing Department, The University, Southampton SO9 5NH to whom applications (7 copies from UK applicants) giving the names of two referees should be sent to arrive not later than 23 June 1986 quoting reference number 1745/A/NS.

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Applications should be made in writing, with a full cv to:

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Enter, a new man at the DES

IT WAS expected: it was overdue. Sir Keith Joseph has vacated the supreme post of education and science. A man of substance and a philosopher, who sometimes forgot his words, Joseph ran out of authority. He leaves much business unfinished. That said, Margaret Thatcher has lost a very considerable political intellect from her cabinet. He became Secretary of State for Education in 1981, and a parliamentarian in 1956: he will stand no more.

Back in 1976, Sir Keith gave a typically philosophical speech on "Moral and material benefits of the market order"—a subject beloved by Thatcherites. In it, he found reason to quote Adam Smith: "It is not from the benevolence but from the self-interest of the baker that we get out daily bread." Last week, Sir Keith's educational and scientific responsibilities passed into the experienced hands of Kenneth Baker.

Although Baker moves across from the Department of the Environment to take up his new post, he is best remembered for his job at the Department of Trade and Industry, where he was the world's first ever minister for information and technology. Then blessed with more than his fair share of energy and enthusiasm, his life was a merry-go-round of opening exhibitions, giving press conferences, talking to industrialists, even appearing on chat shows to spread the word about the glories of information technology. Such was his gusto that at Westminster he became known as Mr Whizz. Hardly a fortnight went by without some new plan being unveiled, with great enthusiasm, that would pour a few million pounds in the direction of companies. That was his job. Baker understands industry, it is said, because he has been both a consultant and a director of a computer company. (This was after a spell as an artillery instructor to the Libyan Army.) But does he understand education or science?

Certainly Baker succeeded in his aim of putting micros into every school in the country. This kind of drive is essential if Britain is to be coerced into the numeracy that will be needed for the 1990s. Baker's well-known skills as a communicator

should stand him in good stead when it comes to overcoming the shortfall of qualified teachers in the sciences. Likewise, he has the capabilities to forge the links that are needed between industry and schools, and industry and academe.

There are, however, many other serious matters that will test the skills of the new secretary of state. What can he do to see that schools get the resources, both human and material, they need (p 20)? What can he do to tackle the apathy in schools, and thence society, for the sciences? Teachers need lots of support to set right the way in which they teach science. Too often, they complain, they have to teach science as if it were in a vacuum just to get their students through the syllabus for their exams. It is the isolation of school science from the realities of everyday life that often leaves the youngsters disenchanted with what seems to them meaningless learning. Likewise, there is the problem that faces industry: universities and colleges are not training would-be employees in the skills, attitudes and often basic knowledge that industry requires of them.

Beyond the realms of pure education, there is much that Baker must do to shore up Britain's national science effort. The time has come to review the interrelations between the various institutions under the research councils, and their links with R&D undertaken in industry and other ministries, such as defence, industry and agriculture. Shall we have, with Baker, someone who can rationalise and fight for an effective chief executive for science, as Hugh Fish, chairman of the Natural Environment Research Council, has suggested (*New Scientist*, 22 May, p 24)? Baker should take heed of the growing backlash among academic scientists to any involvement in SDI. He must tackle the needs of young graduates to find employment. His own experience should help the research institutes who need to sell themselves. As long as the market place rules, scientists and teachers at all levels would do well to remember Adam Smith's percipient words. □

Calling the pot black

RUMOUR is rife that the Test and County Cricket Board (TCCB), in its wisdom, is about to ban Ian Botham from Test cricket for a time (a month or two, a year, perhaps for life) for the heinous crime of admitting that 10 years ago he smoked the occasional cigarette laced with marijuana. The more Machiavellian observers of the cricket scene have already suggested that this is but the thin end of a broad wedge, and that the TCCB hopes to establish the principle that no cricketer who has ever sniffed ganja should be allowed to represent his country—thereby probably wiping out the West Indian cricket team at a stroke. But more serious issues, worthy of at least a passing moment of thought, are raised by the case.

The case of the TCCB, such as it is, is that youngsters who hero worship Ian Botham may be encouraged to follow his example, and try out the illicit weed. The

argument—never proved—is that smoking marijuana leads on to "hard" drug abuse, and therefore by his public statements Botham is seen as encouraging the spread of heroin addiction. A much clearer case, of course, can be made for the fact that cigarettes cause thousands of deaths each year in Britain, dozens of those deaths being to non-smokers, the victims of inhaling smoke from other people's cigarettes.

Advertising tobacco is clearly a worse thing than admitting to having once smoked a joint. And where, in these days of Government Health Warnings and bans on advertising on TV (and in *New Scientist*) do the tobacco advertisers find their biggest outlet? Through sponsorship of cricket, under the direct auspices of the TCCB.

The logic that demands a ban on Botham must also demand a ban on tobacco sponsorship of sport—a ban which we would wholeheartedly go along with. □

THIS WEEK

US and Britain tangle over supercomputers

John Lamb

THE GOVERNMENT is under increasing pressure to resist controls placed by the US on the use of research supercomputers in Britain. The University of London has already refused to ban Eastern bloc researchers from a supercomputer it has on order from Cray Research, an American firm.

The ban, part of American export regulations designed to prevent high technology falling into unfriendly hands, is a condition of sale for the Cray 1 computer. Now, in a bizarre twist to the tale, it has emerged that the Cray 1 ordered by the University of London Computer Centre (ULCC), which Britain's Department of Education and Science will pay for, is not only a second-hand machine but is already in Britain—owned and operated by the Department of Energy. The Cray is a cast-off from the Atomic Energy Authority's Harwell laboratory.

Liberal MP Paddy Ashdown said last week that he would write to the Prime Minister about what he described as a flagrant breach of sovereignty. "We now have a situation in which the government of Britain has to get the permission of the American government to move a piece of equipment it owns from one part of the country to another."

Ashdown said that the Attorney-General, Sir Michael Havers, had already made it clear that Britain rejected American attempts to impose its export laws on equipment already in Britain.

A group of Liberal MPs is attempting to win a debate in the House of Commons on the issue of the ULCC's computer and the impact of the American regulations on academic freedom. The Association of University Teachers (AUT) has also condemned the American action and complained to the Department of Trade and Industry and the Department of

Education and Science.

A document called *Supercomputer Safeguard Procedure* issued earlier this year by the US Department of Commerce, which is responsible for policing American export laws, makes it clear that overseas buyers of American supercomputers are not allowed to issue computer passwords to people from 19 proscribed countries or to share information derived from the computer with them. In addition, computers cannot be connected with the telecommunications networks of proscribed countries.

"It is difficult to police the identities of people who use our computers," says Richard Field, director of the ULCC. "We police the scientific and computational merit of their work, not their origins." Some 2000 scientists use an existing Cray computer at the ULCC, some dialling into the machine from overseas.

A second Cray computer ordered by the Science and Engineering Research Council (SERC) for its Atlas Computer Centre at the Rutherford and Appleton

Laboratory is also the subject of a dispute.

The machine, a powerful Cray X-MP 48, is destined for use by universities and the research councils. "The terms of the export licence are unacceptable to us," said a representative of the SERC.

Officials from the Department of Trade and Industry are attempting to persuade their opposite numbers in the Commerce Department to moderate the conditions for both the ULCC and SERC machines. There had been no response this week. "The ULCC purchase is an internal transfer within the UK," one official said. "The government regards the conditions on this transfer as extraterritorial and we have made that clear."

According to Cray Research, there have been no new restrictions imposed on foreign buyers. The company says that implicit restrictions are now being explicitly stated for the first time.

Last year, similar attempts were made to stop American universities sharing their computer work with colleagues from Communist countries. □

Locusts blossom as rain returns

AFRICA is being menaced by a new threat—four separate plagues of locusts. The locusts are taking advantage of the return of the rains to make a comeback after the years of drought, which affected them as badly as it did Africa's farmers.

The desert locust, which had virtually disappeared after the drought of 1982-84, has reappeared on the Red Sea coasts. At the end of March, locusts were seen in Jordan for the first time since 1968.

The African migratory locust is reviving in the central and eastern plains of the Sudan. Pesticides have failed to protect crops of sorghum and cane sugar from substantial damage. Now the African migratory locust is moving through Uganda, and has appeared in northwest Kenya.

Central and Southern Africa are threatened by infestations of the red locust. Swarms have escaped their traditional breeding grounds in Tanzania and were reported at the end of April in Kenya, for the first time since 1937. Meanwhile, the brown locust is taking flight in South Africa and moving north into Botswana.

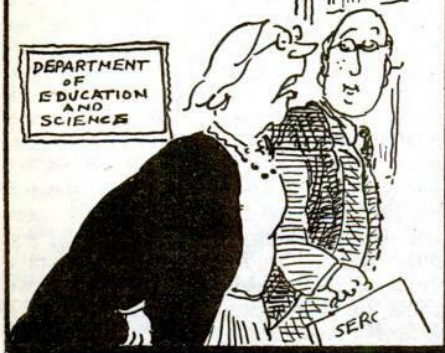
Past experience has shown that locust swarms can travel as much as a thousand kilometres in a single generation: so these four separate outbreaks threaten to become a plague which could affect large parts of Africa. □



OBSERVER David Austin

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DEPARTMENT OF EDUCATION AND SCIENCE



Britain shifts to accommodate binary weapons

SUBTLE shifts of position by British ministers in recent weeks may have helped seal the eventual decision in the US to manufacture a new generation of chemical weapons.

British support for US plans to make binary chemical weapons was a key factor in winning the formal approval of NATO defence ministers for their establishment as a five-year planning target.

Funds to begin production of binary nerve-gas weapons could be released by the US Congress next October. Assembly of the first weapons could begin in October 1987, thus ending a 17-year moratorium on the manufacture of chemical weapons in the US.

Several European states, including Denmark, Norway and the Netherlands, objected to the plans and, with Italy and Belgium, made it clear that they would not allow deployment of binaries in their countries. But Britain and West Germany supported the US. The US administration believes that this support should satisfy Congress, which had made NATO's approval one of the conditions for releasing funds. The binary programme will cost between \$6 billion and \$15 billion.

In binary weapons, the chemical components of the nerve gas are kept separate and mix together only after the weapon has been fired. So far, funds have been allocated for production of 500 000 rounds of 155-mm howitzer shells filled with binary sarin nerve gas, and 40 000 250-kg Bigeye spray bombs filled with VX nerve gas.

These weapons have little military value unless they are deployed in Europe, and the ground has already been prepared for their deployment in Britain and West Germany—the precise conditions are not clear.

Agreement was reportedly reached between President Reagan and Chancellor Kohl during the Tokyo summit earlier this month on the conditions for deployment in West Germany. All old stocks of chemical weapons will be removed by 1992; there will be no deployment of binaries except in times of imminent crisis; any deployment will be subject to Bonn's veto; and West Germany will not be the only European country to accept these weapons.

Rumours of a similar deal between Reagan and Margaret Thatcher have proved difficult to substantiate, but British policy on binaries has clearly undergone a significant shift over the past month. On 28 April, the Minister of State at the Ministry of Defence, John Stanley, said: "There is no question of the deployment of American binary munitions in the UK in peacetime".

In fact, the US has not yet worked out its own deployment plan. The US's ambassador to NATO, David Abshire, told a subcommittee of the US Senate Armed Services Committee on 10 April, that the US was "still developing... the plan for contingency deployment of binary munitions in a crisis situation" and would "consult formally with the alliance once the plan has been completed".

By 15 May, Stanley had come round to the view that any request for deployment from the US would be "a matter for decision by the British government of the day in the light of the circumstances prevailing at the time". Three days later, he said on, tele-

Judith Perera

vision that "the peacetime deployment option" of binary weapons "should be kept open".

The Ministry of Defence conceded last week that there had been a "retreat" by Stanley on this matter. It explained that earlier statements could have "committed a future government" to policies it might not have found suitable and that "a more open-ended attitude" was required.

Deployment of Bigeye bombs in Britain would probably be at the US Air Force bases at Lakenheath in Suffolk and Upper Heyford in Oxfordshire, where F-111 bombers are stationed. In peacetime, the chemicals could be stored at the USAF's storage depot at RAF Welford near Hungerford in Berkshire.

The US has had a series of technical problems with the Bigeye which are not yet resolved. A status report on the bomb by

the US General Accounting Office last June identified the problems as "pressure build up and physical damage to the bomb, uncertain purity/toxicity of the chemical agent, and increased vulnerability of the aircraft as a consequence of technical problems with the bomb."

Pressure build-up is the result of new operational procedures. These will make necessary the delivery of the bomb from a low-altitude, although it was originally designed for high-altitude delivery. At low altitudes temperatures are higher, and tests at these temperatures "disclosed that chemical mixing led to an accelerated buildup of pressure". On one test this led to "a bomb blowout, a forceable ejection of internal bomb components".

The status report says: "We have seen reports that describe internal and external structural damage to the bomb as a result of tests and we have seen reports that mention leaking of the chemicals". □



Nuclear waste could be hijacked by terrorists, says Greenpeace. To prove it, the group boarded this ship in the Straits of Gibraltar carrying 30 tonnes of Italian waste to Sellafield

Pill causes liver cancer—but not often

SUSPICIONS have been strengthened that the contraceptive pill can cause cancer of the liver. Two new studies suggest that taking the pill for eight years or more increases a woman's risk of developing liver cancer. Yet, because liver cancer is such a rare disease in Britain, the risks remain extremely small.

The latest evidence for the link comes in two papers published in last week's *British Medical Journal*. One study looked at past use of oral contraceptives in 26 women, all under 50 years old, who developed a form of liver cancer called hepatocellular carcinoma. It showed that a woman taking the pill for more than eight years has her chance of developing the carcinoma raised 4-4 times.

The other study examined whether those women in England and Wales who died from liver cancer between the ages of 20 and 44 used oral contraceptives. It found that, between 1979 and 1982, long-term pill takers were 20 times as likely to contract liver cancer.

The Family Planning Association says

that the two papers suggest the pill may cause between five and 12 extra deaths each year in England and Wales among women aged 20 to 44. "This must be set against the beneficial effects of oral contraception which include protection against ovarian cancer and endometrial cancer [cancer of the lining of the uterus], diseases which are responsible for 4000 and 1200 deaths respectively each year in England and Wales," says the association.

The Committee on Safety of Medicines, which oversees the safety of drugs in Britain, has not advised doctors to change their prescribing habits.

The first study mentions that a majority of the pill-taking women who had developed liver cancer had taken high-dose brands containing 50 micrograms of oestrogen. Doctors prescribe brands containing 50 micrograms of oestrogen, such as Eugynon 50 and Ovran, far less today. Women are now more likely to take brands that provide a dose of 30 micrograms of oestrogen, such as Ovran 30, Ovranette and Eugynon 30. □

Schools suffer as technical colleges prosper

EDUCATION initiatives by central government in Britain are shifting money and resources from schools to other sectors of education, particularly technical and vocational colleges. They are also creating greater inequalities within schools themselves. These conclusions emerge from a report* published last week by Her Majesty's Inspectorate.

The report expresses concern that schools are now "generally stretched for money and resources". In contrast, further education colleges are judged to be "better provided for".

Non-Advanced Further Education (NAFE) colleges, in particular, have been pin-pointed by the government as a key area for investment. The Manpower Services Commission (MSC), is investing heavily in NAFE colleges because youth training is considered a priority if Britain is to remedy its skills shortage.

The inspectorate further highlights the differences between schools in the opportunities they provide for pupils. Disparities, it says, are widening. One reason cited is that some schools are able to attract more money from parents than others. But another factor is that there are now several government initiatives, notably the MSC's Technical and Vocational Education Initiative, which are channelling substantial amounts of money into those schools willing to cooperate. The initiative is even responsible for accentuating differences within schools.

The report says that, although money and resources are short, these factors limit the opportunities of children

in only a tenth of schools. "Inadequate provision", it says, "is not related to the level of expenditure." The inspectorate instead lays the blame that problem schools face at the feet of teachers. It refers to their "inadequate identification of the pupils' educational needs and potential". Teachers are failing, it says, to target their resources properly. The inspectorate calls for teachers to become better leaders and for better in-service teacher training.

On the whole, though, the inspectorate is happy with the general level of attainment of pupils. "Throughout the system", it says, "the large majority of work was judged satisfactory or better." But, in all schools the work of pupils of below-average ability

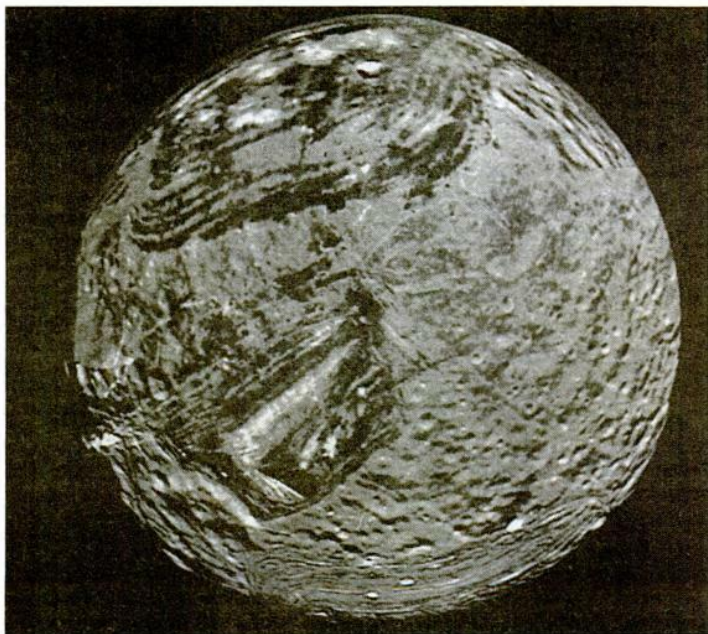
was least satisfactory. Despite warnings by the MSC (*New Scientist*, 18 July 1985, p 24), Britain is still ignoring the lesson of its economic competitors by continuing to gear its education system to the abler pupils.

Schools are surviving by "robbing Peter to pay Paul". Little money, the inspectorate says, is being spent on, for example, the maintenance of buildings, re-decoration and the replacement of furniture. To continue to neglect capital spending is dangerous. According to Sir Keith Joseph, who retired as education secretary last week, Britain already sees in its school buildings "the result of perhaps 20 years of neglect".

The report says "there are many schools with insufficient numbers of books; others with old stocks which cannot be replaced; and many having to choose between the replacement of old stock and the purchase of new books."

Cuts in university spending are not starving the nation of graduates in engineering and technology, says the University Grants Committee. In a letter last week, outlining how it will distribute funds for the coming year, the committee notes: "Until problems of early specialisation and staffing in the schools have been overcome, the demand from qualified candidates is unlikely to increase much."

The committee forecasts that by 1989/90 there will be 14 per cent more places in universities for engineering and technology than were actually filled in 1984/5. □



This is a mosaic picture of Miranda, the innermost and smallest of Uranus's five major moons. It has been compiled by computer from nine photographs taken by the Voyager 2 spacecraft in January. The image looks at the south pole of the moon. Miranda is 480 kilometres across

* Report by Her Majesty's Inspectors on the Effects of Local Authority Expenditure Policies on Education Provision in England—1985 DES, May 1986.

Thymus protein offers a clue to AIDS vaccine

A SYNTHETIC protein that could help the body to attack the AIDS virus might result in a vaccine against the disease. Scientists hope that the protein will help them to develop a safe vaccine that ignores the constantly changing face of the virus and concentrates on attacking its unchanging core.

A puzzling trait of the AIDS virus is its apparent invulnerability to the body's immune system. In fact the virus attacks a subpopulation of the immune system's cells, the T4 cells. The virus also constantly changes its outer coat, confusing efforts to design a vaccine that can identify the virus and eliminate it.

Biochemists at George Washington University in Washington DC and the National Cancer Institute in Bethesda, Maryland, have studied the thymus gland, an organ of the immune system to try to solve the problems of a vaccine. One of the thymus's proteins, thymosin α_1 , helps to regulate T cells. Levels of thymosin α_1 are

depressed in patients suffering from immune deficiency diseases. When Paul Naylor of George Washington University looked for thymosin α_1 in AIDS patients, he was surprised to find high levels of the protein, a finding others confirmed in over half the subjects they tested. One explanation which the research group puts forward in this week's *Science* is that something the AIDS virus produces looks immunologically very much like thymosin α_1 .

Allan Goldstein from the university discovered that the protein created by *gag* gene in the AIDS virus which makes up its core, is very similar to thymosin α_1 .

Rabbits injected with a synthetic version of the hormone created neutralising antibodies to it. Would these antibodies succeed in attacking the hormone's look-alike at the core of the virus?

In fact, the rabbit antisera reduced viral replication in infected human cells by just over a half. When Goldstein mixed the

rabbit antisera with immunoglobulin, a type of antibody, levels of viral protein were reduced by 80 to 90 per cent. These proteins, known as p15 and p24, constitute the virus's inner core and are its "Achilles' heel", says Goldstein.

The enriched version also crippled the production of an enzyme called reverse transcriptase, which the virus needs to reproduce itself. Goldstein believes that a vaccine could be made from either the synthetic thymosin α_1 or from the virus's own *gag* protein.

The likeness between the thymosin protein and the *gag* protein may explain why victims of the disease cannot fight it off. Antibodies effective against the *gag* protein would also attack the thymus, a finding supported by the discovery that AIDS patients suffer significant damage to the thymus glands. Goldstein warns that thymosin α_1 could create a similar response, causing the body to attack the thymus. □

Captain Midnight hijacks satellite TV

THE WORST fears of the US's broadcasting industry have materialised. Someone who calls himself Captain Midnight has started to jam the satellite broadcasts on which US cable stations rely for their programmes.

The jamming is in retaliation for the decision by one provider of programmes, Home Box Office, to scramble its signals. This put a stop to amateur poachers of programmes, and ensured that only cable stations or viewers with private aerials who have paid Home Box Office for a decoder can tune into its programmes.

Several hundred thousand people in the US have paid thousands of dollars to install "backyard" dish aerials capable of receiving Home Box Office and similar stations. Earlier this year the company began scrambling its signals and asking \$12.95 a month for a decoder. Other programme providers plan to follow its lead.

Now the companies may have to think again. Captain Midnight has proved that it is technically possible for third parties to hijack a broadcast satellite and hold the cable industry to ransom.

Sales of "backyard" dish aerials plummeted as soon as Home Box Office began scrambling in January. The company received anonymous threats that its services would be sabotaged. Engineers did not take them seriously. They believed it would need a very powerful signal from a very large dish to override the legitimate signal being sent up to the satellite and "capture" its receiver. But recently, during a broadcast of the feature film *Falcon and the Snowman*, the picture

disappeared for five minutes and was replaced by a test pattern and the words "Good evening from Captain Midnight. \$12.95 a month? No way. Showtime Movie Channel Beware." The Showtime Movie Channel intends to start scrambling this week.

Engineers from the US Federal Communications Commission believe the hijack, which they call "video terrorism", needed at least 4 kilowatts of transmitter power and a dish at least 5 metres in diameter. What they are reluctant to admit is that there is no way of detecting a hijacker who operates in short bursts. A transmission dish looks exactly the same as a reception dish. If the beam is tightly focused, by a large dish accurately aimed at the satellite, a skilled amateur may be able to interrupt services with a low power jammer and virtually no fear of detection. A hijacker with inside knowledge may even be able to send up signals which would switch the satellite off or alter its position in orbit so that all ground aerials needed realignment.

The successful hijack will worry providers of cable programmes in Europe. They have been planning to scramble their signals as soon as enough people in Europe have bought backyard dishes to make it worthwhile.

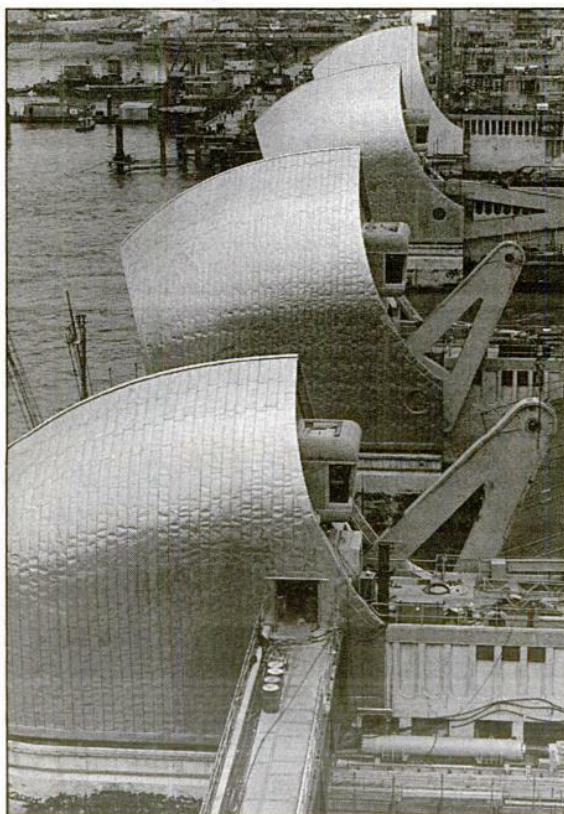
So far only Rupert Murdoch's Sky Channel is scrambled. Last year, an unknown Earth station sent signals up to the satellite handling Sky's channel so that Sky could not transmit. The hijacker soon stopped and was never caught. He has not struck again... yet.

Ministers want to dismember pollution controls

WATER authorities are digging in their heels against government plans to exclude land drainage and flood protection (including works such as the Thames Barrier) from privatisation of the industry. Senior figures in the industry say that privatisation should be "all or nothing", so that they can retain their control over the use of water. "Our system of integrated river basin management is the model for the rest of the world," says Len Hill, the chairman of the Water Authorities Association.

The separation of land drainage from other aspects of the control of rivers, including pollution control, could result in major damage, he said.

Ministers have promised that pollution control will remain a top priority after privatisation. But in much of Britain farms are the most important source of river pollutants. This pollution reaches rivers through land drains. If the water authorities "pollution police" lose control of drainage, they will lose their power to curb the worst excesses of farmers, water chiefs fear.



Thames Barrier may stay in public hands

AIDS linked to VD

A STUDY of a group of homosexual men in London has found evidence to support the theory that people who become ill are more likely than others to catch AIDS if they come into contact with the virus. The researchers conducting the study say in last week's *The Lancet* that the best prediction of whether someone is susceptible to the virus is whether they have a history of infection, particularly with sexually transmitted diseases.

Researchers from St Mary's Hospital and Medical School in London have followed the fate of 170 homosexual men since 1982. At the beginning of the study none of the patients showed any symptoms of AIDS, but 33 of them had antibodies to the virus, meaning that they had come into contact with the virus.

Over the next three years, another 15 men developed antibodies. Of those with antibodies, 24 showed signs of AIDS infection and four developed the full-blown disease.

The researchers found that a good predictor of whether someone at risk of developing AIDS actually does so is whether they have already suffered infections, particularly sexually transmitted ones. "This finding implies the intercurrent infection may play a role in seroconversion [developing antibodies] after exposure, and in progression to symptomatic disease. ... These intercurrent infections may activate latently infected T4 cells ..."

Minerals saved

GOOD NEWS for British mineralogy: the fine private collection of minerals from mining in Devon and Cornwall is not to be sold abroad. Earlier this year, it seemed that the collection, amassed by the Cornish amateur mineralogist Richard Barstow who died in 1982, would be split up and sold abroad unless support could be found for a bid that the Plymouth City Museums and Art Gallery were making to secure it (*New Scientist*, 20 February, p 15).

The museums had until 24 April to raise the £70 000 asking price for the collection. By 23 April, Tristram Besterman, the museums' curator, had raised £28 500. Then the city council's finance committee decided to vote the balance of £41 500 enabling museums to buy the collection.

Sellafield falls out

CUMBRIA County Council wants a ban on the production of plutonium for nuclear weapons at the Sellafield reprocessing works. The council wants the plant to switch its work towards the long-term storage of Britain's stockpiles of nuclear waste. But it has also agreed to make urgent investigations of prospects for alternative employment in West Cumbria. "After Chernobyl, nothing will ever be the same again," said one councillor.

The council is also calling for better management and less secrecy at the plant and more investment to contain pollution.

Atom agency gets tough

THE INTERNATIONAL Atomic Energy Agency is considering setting minimum safety standards for nuclear reactors that would be binding on all states that are members of the organisation. The proposal came to the fore during an emergency meeting of the agency's board of governors last week.

The board also agreed to convene a special "post-Chernobyl review meeting" at which Soviet engineers and scientists will present their detailed findings on the cause of the disaster to a group of atomic experts from member states.

Much of the pressure for greater international cooperation over nuclear safety is coming from the Soviet Union itself. Ideas include committing nations to providing information about accidents, and requiring international cooperation to provide emergency assistance after an accident.

Germany fights over the future of nuclear power

THE ACCIDENT at the Chernobyl nuclear power plant caused its largest number of known casualties so far last week—in West Germany. In violent demonstrations at the site of the proposed reprocessing plant at Wackersdorf in Bavaria, 400 people were wounded, 62 of them police. Tear gas was eventually sprayed on an estimated 20 000 demonstrators from helicopters.

There is nothing new about protests at Wackersdorf. A more-or-less peaceful encampment has been there since construction began last December. What has changed is the level of fear and mistrust of nuclear power in the wake of Chernobyl. Klaus Koerting of the Nuclear Research Centre in Karlsruhe, describes Chernobyl as “an information disaster” in Germany.

There were many conflicting reports of safe and actual radiation values broadcast in Germany following the accident. Scientists of the Federal Radiation Protection Commission said nothing in the first few days, because “they had to wait to be certain of the measurements first, to protect their reputations,” say nuclear experts in Germany.

Politicians had no such qualms, and the advice given to Germans varied with local politics. The federal safety limit for radio-nuclides in milk, for example, is 500 becquerels per litre. The state of Hessen, where Joschka Fischer of the Green party is environment minister in a shaky coalition government, decided that nothing more than 20 becquerels was safe. People in other states wondered who was right.

The uncertainty added to latent public misgivings in Germany, where a highly

Debora MacKenzie, Geneva

industrialised society coexists with a strong “techno-phobia”. Public opinion swings easily. Before Chernobyl, 56 per cent of West Germans were in favour of more nuclear power stations; now only 29 per cent are.

The first victim of the switch could be the fast-breeder reactor at Kalkar. It is complete, but so far without a full licence



The rioting worsens as Germany discovers “techno-phobia”

from the state government (*New Scientist*, 24 April, p 20). The state is expected to decide next month whether to let it start up. The head of the state government is Johannes Fau, who hopes to replace Chancellor Kohl in general elections next year.

Without Kalkar, the future of the Wackersdorf reprocessing plant may come into question. Its functions are both to produce fast-breeder fuel, and to handle spent fuel elements from light-water reactors. But the driving force behind Wackersdorf is the fast breeder, according to Klaus Koerting.

Wackersdorf is expected to handle 350 tonnes of spent fuel a year, making it much smaller than its French or British equivalents. All spent German fuel is currently reprocessed in France. German law does not permit it to be disposed of until it has been concentrated by reprocessing. With both France and Britain planning extra capacity in the near future, not everyone believes Wackersdorf is needed at all.

The plant would be a test site for some new technology, however. It will use the same Purex technology, as other reprocessing plants. In this method, nuclides are dissolved in acid and then extracted with solvents. However, at Wackersdorf the acid-fuel solution will be poured down a column of solvent, rather than fed into the more common mixer-settlers, says Koerting. Sieves in the column will create turbulent flow to knock nuclides into solution. This will be safer because it involves fewer moving parts, he says.

Peter Schmidt of DWK, the company building the plant, says it will incorporate remotely-handled modules for safer repair and operation. In addition, Wackersdorf may employ a new technology for driving the nuclides into the solvent. The method, developed at Karlsruhe, uses electrical current, and will cut down on the amount of waste to be disposed of.

More than anything, the fate of Wackersdorf depends on the mood of German voters. “I doubt if another nuclear plant will be built soon in West Germany, the way things are now,” says Koerting. Power stations under construction in Baden-Wurtemberg, Schleswig-Holstein and Bavaria may be threatened. □

France discovers the nuclear scare

REVELATIONS of contamination, official secrecy and a barely-averted meltdown of a French nuclear reactor in 1984, last week rocked a French public that has been nonchalant about its huge nuclear industry.

The French were complacent in the days after the accident at Chernobyl. Television showed farmers and mothers shrugging calmly against the backdrop of the local nuclear plant.

Initial reports from the French radiation protection service said there were no significant radiation increases in France, even though there were reports of increased radiation in all its eastern and southern neighbours. The World Health Organisation's report on contamination on 6 May had data from every country in the region except France.

It took until 13 May for Pierre Pellerin, the service's director, to admit that the cloud from Chernobyl had deposited radiation in Alsace and southeastern France up to 400 times normal levels. Alsatian spinach was taken off the market on 15 May.

On 20 May, five workers at the nuclear

reprocessing plant at Cap La Hague on the Channel coast were irradiated after radioactive liquid escaped from a disused pipe. The men kept working for some time because their personal alarms did not sound.

One worker received 18 rems on the body, 272 on the hands. The allowed annual doses for workers at the plant are 5 rems on the body, and 60 on the hands.

The biggest revelation last week came from the newspaper *Le Canard Enchaîné*, which reported a confidential report on a hitherto unknown incident in 1984 at a reactor at Bugey, near the Swiss border. Francois Cogné, the head of the Institute for Nuclear Security and Protection, which made the report, confirms the paper's assessment that it was “the most serious accident yet in a French reactor”.

On the night of 13 April 1984, the 900-megawatt reactor number 5 at Bugey had to be shut down. It happened after a series of electrical failures in the control panel, following which, a pump that sent cooling water to the pressurised-water reactor failed. To prevent a meltdown, the

residual heat in the reactor had to be removed with coolant.

One backup electric system failed, however, because current to the control panel had failed. The second, a diesel generator, did not work. The third backup system, another diesel generator, started. The report says an “uncontrollable situation” would have ensued if it had not. *Le Canard* notes that “it is fortunate the incident didn't happen in winter”, when the diesels rarely start because “it seems the fuel freezes”.

The incident was not over yet, however. The report reveals that while the coolant pump was out of action, pressure in the reactor mounted and opened relief valves. These were the same sort of valves that stuck open and caused the accident at Three Mile Island in 1979. Because of that accident, the French valves were equipped with controls to re-close them. These did not work, however, because they were controlled by the same electrically defunct control panel.

A week later, the reactor was back in service. □

In search of a public image

After Challenger and Chernobyl, science has a lot of explaining to do. But when 3500 members of the US's scientific community congregated in Philadelphia this week for the annual meeting of the American Association for the Advancement of Science (AAAS), they found they had lost their voice in government

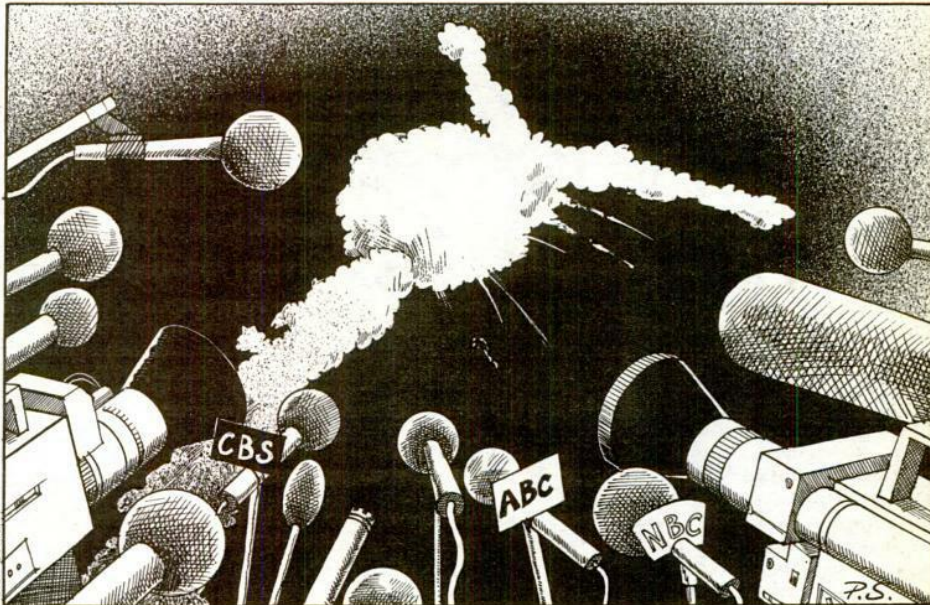
Christopher Joyce and Fred Pearce, Philadelphia

FOR THE SECOND time in five months, the science adviser to the White House has quit to seek greener pastures in business. Last week, John McTague, who has been acting director since George Keyworth II left the post, decided to take on the job of research director at the Ford Motor Company. Keyworth, who had held the job since Reagan's first election, left to start a consulting firm for businesses.

The job of advising the White House on matters scientific has failed to draw the interest of qualified applicants. At the meeting this week of the AAAS in Philadelphia, the greybeards of the country's biggest science organisation bemoaned the regulation of the office to a public-relations enterprise that increasingly sells military research to the public.

During previous presidencies, recalled David Hamburg, outgoing chairman of the AAAS's board of directors, the adviser's office was one "that could be troublesome. It's supposed to be troublesome" to the political establishment. Now "it's a weapons job", he said, whose availability no longer keeps "world-class" scientists waiting for a phone call from the White House.

The government now has no focal point to debate the future of the space programme, the effect on nuclear power of the accident at Chernobyl, or the damage to science from budget-cutting in Washing-



No focal point for debating the future of the space programme

ton. William Carey, publisher of *Science*, America's scientific journal of record, observed that former government appointees say they would not go back now. Their reluctance, according to a recent study, is mostly due to restrictions on what they can say publicly, what they can publish, or their contacts with business,

Carey said.

McTague refused to say what his salary at Ford will be, only that it was more than his White House salary of \$73 600. President Reagan has promoted Richard Johnson, an assistant director of the office, to replace McTague while the search for a permanent adviser continues. □

Chemical industry twists its risk factors

HOW SAFE is safe? The answer, for factory workers relying on assurances from their employers or the government, may not be safe at all. So argued Deborah Mayo, from Virginia State University.

Mayo took as her text the reassurances of the Du Pont chemical company that its workers were at no risk from their exposure to formaldehyde at work and a decision of the US government in 1981 to remove the chemical from a list of likely hazardous substances.

The key to the formaldehyde issue, she said, was "understanding a negative statistical result". Du Pont conducted a survey of the risks of dying of cancer among workers who had been exposed to formaldehyde, but found "no statistically significant association between the chemical and cancer. In other words, nothing that could not reasonably be put down to chance."

Du Pont reported that the data "suggested that cancer mortality rates in the company's formaldehyde-exposed workers were no higher than the rates among non-exposed workers". The results "supported the conclusion" that employees were safe.

This conclusion, says Mayo, is nonsense. "Failure to find a statistically significant

increase is not the same as having positive evidence that the increased hazard is zero... the test may have a very small chance of finding a statistically significant difference..."

"The Du Pont study had only a 37 per cent chance of detecting a two-fold increase in relative risk of dying of cancer, and practically no chance (4 per cent) of detecting a two-fold increase in cancer of the pharynx

or the larynx."

The study had an 80 per cent chance of detecting a three-fold increase in the relative risk of lung cancer. But to have a similar chance of picking up an increase in cancer of the larynx, the workers would have to be at 42 times the risk. For cancer of the pharynx, the risk would be 57 times the average before you could be 80 per cent sure of picking up the difference. □

Scientists as self-deceivers

A SESSION on self-deception briefly turned the spotlight on the foibles of scientists themselves.

Michael Mahoney, a professor in psychology at the University of California at Santa Barbara, reported asking reviewers for a social science journal to evaluate the write-up of a bogus experiment. He sent half the reviewers write-ups that included data and conclusions that agreed with accepted theory. The other half had data and conclusions that conflicted with current thinking.

"When the results were contrary to the reviewers' theoretical beliefs, the procedures were criticised and the manuscript rejected. But when the results

confirmed the reviewers' beliefs, the same procedures were praised and the manuscript recommended for publication."

In a second study, Mahoney gave reviewers manuscripts in which only the footnotes varied. Half included citations to work "in press" from the manuscript's author. In the other half, the references were to other people's work, but otherwise identical.

Mahoney found that the reviewers gave consistently higher ratings to papers with the author's own work cited. "Even in science, nothing succeeds like success. Publication begets publication, recognition begets further recognition, and the rich get richer" he said. □

Mathematical genius: in the hormones?

B RILLIANT mathematicians are likely to be male, to suffer from allergies, to be left-handed and to be myopic. A study of more than 100 000 extremely bright American children comes to this highly contentious conclusion. Camilla Benbow from Iowa State University, who works on the Study of Mathematically Precocious Youth, suggested that exposure in the womb to high amounts of testosterone, the male hormone, could be the linking factor.

The results of more than a decade's use of the Scholastic Aptitude Test among America's brightest 12-year-olds seems to go a long way to undermining the idea that social conditioning is the prime reason why boys do better than girls at maths and sciences. Biology may be the key.

One startling finding is that the higher up the ladder of mathematical reasoning ability you go, the more boys outnumber girls. Among the top 3 per cent of achievers in the nation, there are two boys to every girl. Among the top half per cent the ratio is four to one. Among the top 0.2 per cent, it is 13 to one.

When the same tests were conducted in Hamburg and Shanghai, they produced similar findings, said Benbow. A series of studies has failed to find evidence that social conditioning explains the differences in performance in mathematical reasoning. Boys and girls reported enjoying (or not enjoying) maths to a similar extent, and to receiving similar amounts of parental

encouragement, although neither enjoyment nor encouragement seemed to have much effect on performance among the highly able. Benbow says she has also failed to find evidence that early preferences in toys has much bearing on the matter.

Benbow finds that physical features correlate much better. "Mathematical reasoning ability is probably more strongly

in the general population. The better they are, the more left-handers there are.

Left-handers are known to suffer more from immune disorders, and Benbow has found that "extremely precocious mathematical reasoners were about twice as likely to have allergies as members of the general population."

Norman Geschwind and other biologists have recently suggested that left-handedness and immune disorders are related to exposure of the fetus to high levels of testosterone. "They suggested," says Benbow, "that testosterone slows the development of the left hemisphere of the brain and thereby enhances the development of the right. It simultaneously affects immune development."

"Since left-handedness and allergies were related to extremely high levels of mathematical reasoning ability, prenatal exposure to high levels of testosterone may be another correlate of extremely high levels of that ability. Since testosterone is the male hormone, this suggests an obvious connection between it and the sex difference in mathematical reasoning ability."

Benbow concedes that scientists cannot ignore social factors. "There are well documented differences in the socialisation as well as the biology of boys and girls. We propose that it is a combination of both these factors that causes the sex difference," she says. "If biological factors are involved, it does not mean that efforts at remediation cannot make a difference. They probably can and ought to be tried." □



All the signs of a genius in the making

Sally & Richard Greenhill

under the influence of the right hemisphere of the brain in normal right-handers," she said. Because left-handers may show an advantage on tasks mediated by the right hemisphere, it seems reasonable to expect that left-handers have an advantage on mathematical reasoning tasks. Sure enough, among the precocious mathematical 12-year-olds, 16 per cent are left-handed—more than double the proportion

Insulating gene takes its toll on Indians

EPIDEMICS of diabetes and gall stones among American Indians from Alaska to Mexico are being blamed on a common gene, developed after the Indians crossed the Bearing Straits in to America 20 000 years ago. The gene may have helped Asians survive the cold Arctic winters, but seems to have left them especially vulnerable to "diseases of civilisation" now that they are well-fed on modern diets. Both epidemics began about 50 years ago.

The claim was made by Ken Weiss, a professor of anthropology at Pennsylvania State University, during a discussion on the diseases of civilisation. "An excess of calories and less physical activity produces an accumulation of energy in the body as body fat, and this can cause diabetes. But for some reason the American Indians, along with the Polynesians, seem to be at special risk," he said.

"In some American Indian populations, almost 100 per cent of people can expect to get diabetes if they live long enough." The disease seems to go hand in hand with gall stones and with gall bladder cancer, which is usually fatal. Among some American Indians, 90 per cent of women will have stones by the time they are 70.

Weiss believes the cause of the epidemic

is modern lifestyles, notably diet, combined with extreme genetic susceptibility—a susceptibility which the American Indians do not seem to share with the ancestors they left behind in Asia. "Japanese and Chinese living in the US do not succumb to these diseases in this way," he says.

"We haven't found the gene, so this must remain speculation," he admits, "but perhaps in the Arctic conditions they experienced after their migration, the American Indians developed an efficient method of food storage in their body by building up a layer of body fat. The gene that offered this provided a selective advantage

at the time and did no harm until today, when there is basically a surfeit of food and the gene becomes detrimental."

American Indians today are often fat and diabetic. But their health improves if they eat less and take more exercise.

Weiss argues that the spread of diabetes, widely seen in modern societies but evident in an extreme form among American Indians, may be tied to other diseases of civilisation. "Centripetal fat, that is fat around the trunk, does seem to be linked not only to diabetes but also to hypertension and to obesity," he said. □

America's surgeons keep on cutting

D OCTORS perform 700 000 hysterectomies in the US every year. The operation has never been properly evaluated by researchers. Some 200 000 patients have coronary bypass surgery every year. Yet important questions about the effectiveness of the procedure remain unresolved. While governments have set rigorous rules for checking the safety of new drugs, "there are no laws to protect patients from inappropriate use of [medical] procedures", said Valerie Miké, a professor

of biostatistics at Cornell University.

Miké attacked the poor quality of much medical research. "The usual issues are small sample size and inadequate design."

Across the US, there are ten-fold differences in the rate of operations such as hysterectomies, prostatectomies and tonsillectomies "with no discernible effect on the general health of the population," she said. This "provides support for the view that much of today's treatment is ineffective." □

How America nurtured AIDS

THE "SERIOUS FAILURE" of the American public health system to control venereal disease among homosexuals set the stage for the current epidemic of acquired immune deficiency syndrome (AIDS).

The accusation comes from Lewis Kuller and Lawrence Kingsley, professors of public health at the University of Pittsburgh. "We just don't care about venereal diseases," Kuller said of American society. "We wouldn't care about AIDS if it didn't kill people."

As a result of this neglect, the AIDS virus found a ready-made home: active homosexuals with multiple partners who practised anal intercourse, which, alongside the sharing of needles by addicts, is considered the best means of transmission.

Homosexuals in San Francisco and New York made some attempts to alter their sexual practices quite early in the AIDS epidemic, and rates of rectal gonorrhoea subsequently dropped. But these measures have been inadequate, and rates of infection continue to rise.

While describing the epidemiology and identifying the virus moved quickly, said Kuller, "the failure of any attempt at an effective public health control programme may be a measure of the weakness of our public health system." The AIDS virus may now infect as many as 1.5 million Americans. Most have yet to show symptoms, but must be considered potential carriers.

According to Ronald Bayer of the Hastings Center, about 70 per cent of homosexuals in San Francisco and New York City are now infected. About 70 to 80 per cent of drug abusers, who account for about 17 per cent of AIDS victims, are infected.

The US government, says Kuller, spends about 3 per cent of its AIDS war chest of \$200 million on education. Most of the rest goes to the glamorous pursuit of a vaccine and drugs to treat the disease.

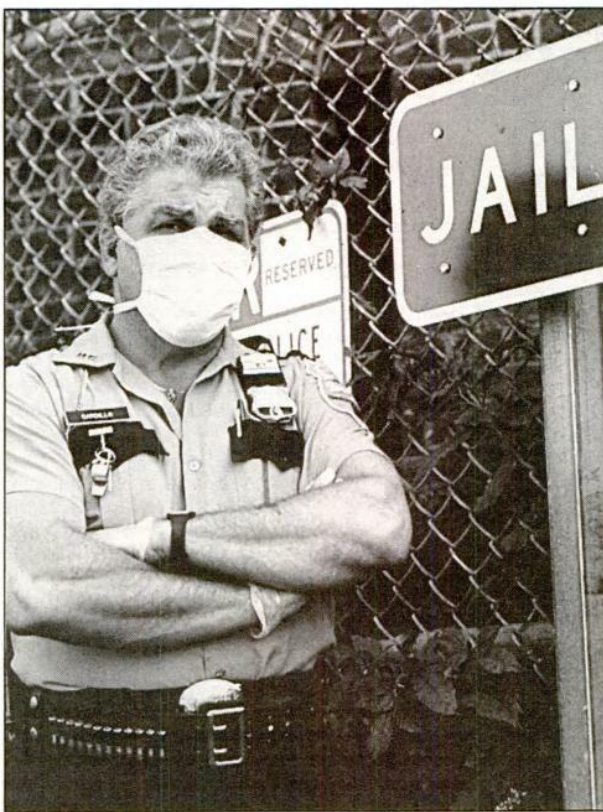
It is unlikely that education can now turn back the tide in homosexual populations in San Francisco and New York. The main effort now must be to stem the disease's spread to homosexuals in other parts of the country, where rates already have begun to rise. This requires the painstaking task of identifying infected people and tracing their sexual contacts.

"Orwellian" attempts to quarantine those who are seropositive—who have been exposed—will only keep them from cooperating, said Kuller.

The scope of the job is daunting. In the state of Pennsylvania, 400 cases of AIDS have been reported. Assuming from experience that some 100 people in high-risk

groups are infected to every reported case of the disease, 40 000 people could be infected. A "case-contact" history would have to follow a massive screening programme to find those 40 000. An alternative would be to screen all homosexuals. In Pennsylvania, they probably number about 130 000. Informing this group of their potential to transmit the disease would accompany screening.

Kuller and Kingsley note that people who are seropositive—that is, with antibodies to the virus but without disease—are probably a lesser threat to the community than the social drinker who drives after a party, a cigarette smoker who pollutes a room, or an adolescent with access to a pistol. The panel observed ruefully that some communities are reviewing AIDS literature circulated among high risk groups and rejecting what they find



Confinement raises difficult questions

"offensive", a puritanical reaction which Bayer described as "crazy".

● More than 3 million people around the world suffer from AIDS, a meeting in Bethesda, Maryland, heard last week.

Experts including Thomas Quinn of the National Institutes of Health and Luc Montagnier of the Institut Pasteur in Paris agreed that the number of 25 000 confirmed cases should be multiplied by at least 100 times to give a fair picture of the disease's spread.

New evidence is emerging from project SIDA, a multinational study of AIDS in Africa. One suggestion is that mosquitoes do not carry the disease. The project has found that the group most at risk of malaria, young children rarely develop AIDS.

Off our backs

ATTEMPTS by American companies to keep people with bad backs off their payrolls could be an important cause of childhood leukaemias. To add insult to injury, the screening of workers for susceptibility to pain in the lower back by X-raying them does not even work well.

Nobody knows how many X-rays of the lower back are carried out by American companies. One estimate put it as high as a million in 1973. That year, according to Roger Kasperon, director of the Centre for Technology, Environment and Development at Clark University, the Missouri Pacific Railroad alone carried out 20 000 X-rays of the lower back among applicants for jobs. It rejected 40 per cent on the basis of the results.

Researchers now know that the method is very bad at predicting future back pain or disability. Even so, says Kasperon, "the incentive is still strong" to do the screening because the costs of compensation for workers who later damage their backs at work is high.

Meanwhile, he points out, "lower back X-rays are the largest single source of gonadal irradiation in the US and a significant source of childhood leukaemia due to exposure of the fetus."

Trauma purge

POURING out your heart is good for your body as well as your soul. James Pennebaker, from the Southern Methodist University, reported asking college students to spend 15 minutes on four consecutive days writing down their deepest thoughts about some traumatic event in their lives. He found that over the next six months they visited doctors significantly less often than a control group of students whom he asked to write about superficial topics.

Growing pains

CHILDREN who become sexually mature at a young age seem to run an increased risk of high blood pressure, hypertension and heart disease in later life. The reason could be hormones released from the child's adrenal gland, starting at around eight years old.

Solomon Katz, professor of anthropology at the University of Pennsylvania, claimed that because children mature younger in modern well-fed societies, they seem to be at greater risk of heart disease in later life. "Blood pressure rises in children after six and eight years old as the pattern of secretion of adrenal androgens develops," he said. "Children with high levels of the hormone tend to be fat children at this sensitive period and to mature earlier."

There is evidence, too, that raised blood pressure found in childhood and adolescence is related to the amount of the hormone in the body, and that it leads to high blood pressure in adulthood and hypertension later. "It suggests that we can identify a child that is at risk of developing hypertension in later life—and so could perhaps avoid it."

NEXT WEEK

America's biggest scientific club continues its deliberations.

Among the topics under discussion:

Biotechnology in agriculture

Nuclear power after Chernobyl

A foothold on Mars

The structure of the Universe

Chemistry of cooking, and other everyday sciences

New Scientist's team will be there to record the highlights.

SCIENCE

Female ladybirds choose mates according to plan

THE common or garden ladybird *Adalia bipunctata* is red with two black spots. In a large population, however, there are atypical, melanic forms that are black with four red spots (*quadrimaculata*) or six red spots (*sestupunctata*). Just glancing at the melanic forms you would not think they were even the same species as the typical ladybird, and yet the average female ladybird not only recognises them as her own species but actually prefers the dark forms as mating partners.

The basis for the preference is genetic, as Michael Majerus and Peter O'Donald showed four years ago. They increased the preference from 20 per cent to 50 per cent by straightforward artificial selection. This is exactly the result needed by R. A. Fisher's theory of sexual selection, which states that male sexual adornments can be selected for simply because females prefer to mate with males that have the character in question. Now the Cambridge geneticists have shown that the genetics of female choice is quite simple, and female choice could also be responsible for polymorphisms that are not simply male sexual adornments (*Nature*, vol 321, p 164).

Majerus and O'Donald, with Peter Kearns and Heather Ireland, repeated the original experiment. After 10 generations, they selected several pairs from the high-preference line and gave their offspring a choice between typical and melanic males. The results from these so-called isofemale lines showed wide variation; some mated almost exclusively with melanic males while others had no preference and mated at random. Still other lines had an intermediate level of preference. Looking at these lines in detail revealed a pattern beneath the variation. All of the lines fell into one of four groups.

Some showed no preference at all. These form group 1. In other lines, 32 to 43 per cent of the females preferred melanic males; these go into group 2. The third group contained lines in which 50 to 65 per cent of the females preferred melanic

males. Finally, some lines have between 80 and 94 per cent of the females preferring melanic males. This is group 4.

Majerus and his colleagues explain the four groups as being the expected outcome if preference is controlled by a single dominant gene. Females that carry the gene show a high level of preference (about 85 per cent) and those that do not, mate at random. In the wild, unselected population the preference level is about 20 per cent, which implies that about a quarter of the females carry the preference gene. Once artificial selection has raised the preference level to about 50 per cent, as in the experimentally produced "high-preference" line, just over a third of the females would carry the preference gene. Matings in this population would produce, according to simple laws of genetics, four distinct types of offspring line.

In a quarter of the lines (24 per cent) all of the females would have the preference gene. Preference levels would be around 85 per cent. A fifth (21 per cent) of the matings would produce lines in which three-quarters of the females would have the preference gene. Preference levels would be around 65 per cent. Two-fifths (38 per cent) of the matings would give rise to lines in which half the females have the preference gene. Preference levels in this group would be around 43 per cent. And the remainder, 17 per cent of the matings, would show no preference because none of the females would be carrying the preference gene.

So, theory predicts that the number of lines in groups 1 to 4 ought to be in the ratio 17:38:21:24. In actual fact the numbers are 4:9:4:4, an impressively good match between prediction and observation.

This new study demonstrates that a single dominant gene may well be sufficient to account for the great variability of female ladybirds' mating preferences. Fisher's theory thus gets some extra support. It does more than that, though, because in ladybirds—unlike peacock tails and other favourites of sexual selection—the polymorphism is not restricted to the males. Both sexes show the



Ladybirds prefer black; but choice lies in one gene

different colour patterns. Sexual selection may therefore be more widely responsible for polymorphisms that are not associated with sexual display.

More importantly, perhaps, Majerus and his colleagues draw attention to the wider ramifications of their discovery. Models in evolutionary biology often depend on alternative strategies—for example "hawk" or "dove" in a fight—that are both complex and inherited. Critics of sociobiology have made much of the unlikelihood of genetic polymorphisms for such complex behaviour. "But", as Majerus and his colleagues point out, "female choice behaviour in *A. bipunctata* is certainly both genetic and polymorphic." □

Yellow dye marks the trail to a better test for cancer

RESEARCH into how mice get liver cancer is leading towards what could be a sensitive new test for the potential of food additives to cause cancer.

Zhores Medvedev and his team at the National Institute of Medical Research (NIMR), London, began the research by investigating strains of mice that develop spontaneous liver cancer or hepatic carcinoma as they grow old. In those strains, 50 to 70 per cent die of cancer.

Medvedev found a protein in the nuclei of mice that increases six- or seven-fold with the onset of cancer. It seems to be closely associated with chromatin, the protein backbone of chromosomes. Medvedev speculates that the protein might be involved in repairing genetic damage or in detoxifying carcinogens.

In normal mice, levels of the protein build up slowly. But in mice used for testing

the potential of chemicals to cause cancer, the protein begins to accumulate in liver cells quickly, and long before cancer is apparent. So a test for the protein could be a sensitive indicator of carcinogenicity.

Medvedev says that: "It is very irrational to test chemicals on mice and declare them safe for human consumption". A mouse might die of old age long before a slowly-growing tumour appears. But people may be exposed to the same chemicals for 70 or 80 years. Moreover, different species have varying abilities to defend themselves against carcinogens. The additive the researchers have been using in their tests at the NIMR, butter-yellow azo dye, can cause cancer in mice after 11 months. But rats and hamsters succumb after only three months. And people could be the most sensitive of all.

The liver is the main organ of detoxifi-

cation in the body, so it bears the brunt of chemical attack. One factor that could be significant in minimising the effects of genetic or chromosomal damage in liver cells is the number of genes and chromosomes present. In most cells, there are two of each chromosome. Liver cells, however, can have multiple copies of each chromosome. The highest number of copies in people is eight. But, in mice, numbers of copies often reach 32 or even 64. That means the cells can withstand a lot of damage without affecting their functions.

It also means that in the long term, high doses of carcinogens are required before their dangers show up as tumours. They affect the newly-discovered protein much sooner, however, and levels begin to rise. The protein is easy to spot in electrophoretic tests as it is tightly bound to chromatin.

Martin Redfern

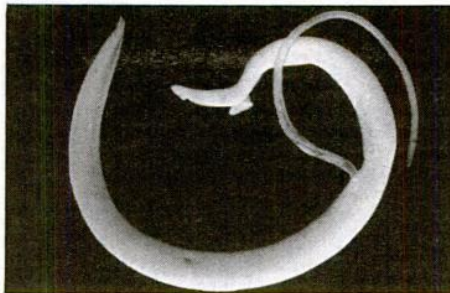
How the body puts the pressure on parasites

PARASITES are primarily a problem in the poorer parts of the world. But, because they are relatively unimportant in developed countries, research into the mechanism of immunity to parasites has lagged far behind work on immunity to bacteria and viruses. Researchers at the National Institute for Medical Research (NIMR), London, have recently made some important discoveries about the control of immunity to schistosomiasis (bilharzia), a tropical disease caused by a parasitic fluke called a schistosome.

Researchers already knew that T cells (white blood cells) recognise schistosomes and stimulate a class of white blood cells, the B cells, to label them with antibodies. Once labelled, yet another class of white cell, the eosinophils, home onto the antibodies and attack the parasites. Now, Colin Sanderson, of the parasitology division of the NIMR, has discovered that when T cells identify the presence of schistosomes, they produce a lymphokine (a messenger molecule) that stimulates bone marrow to switch more of its production of white cells over to making eosinophils. The increase in eosinophils boosts the body's immune response to the parasites.

Immunologists have identified 10 lymphokines produced by T cells. Four of them, including the newly-discovered lymphokine, act as messengers between T cells and other white blood cells. These are known as interleukins. Sanderson calls the new compound Interleukin 4, or IL-4. IL-4 not only stimulates bone marrow to make eosinophils, it also stimulates the B cells to proliferate and produce antibodies against the schistosomes. Stimulated B cells also produce immunoglobulin E (IgE). This explains why high levels of IgE and of eosinophils are always found together in allergic conditions. Clearly, allergens stimulate the same kind of response from T cells as schistosomes and other parasitic worms.

The fact that IL-4 made in mice stimulates human cells in culture shows that this lymphokine is highly conserved—that is, it has remained the same for a long time in



Schistosome worms, attacked on all sides

C. J. Webb

evolutionary terms—which suggests that it has a vital function in animal and human health. Sanderson suggests that the price we pay for our ability to acquire immunity to parasites is our liability to allergies.

In the same department of the NIMR, Ron Smithers has made a discovery which changes current ideas about how a vaccine might be made to protect against schistosomes. Until now, most researchers have concentrated on identifying protein anti-

gens on the surface of schistosomes which they might be able to clone to make a vaccine. Smithers has found that in people chronically infected with schistosomes, most of the antigens against which antibodies are made are carbohydrate, not protein. Moreover, these carbohydrate antigens are common to all the species of schistosomes that infect people. Smithers has been able to show that three monoclonal antibodies which protect mice passively against infection with schistosomes recognise carbohydrate antigens.

This work, says Smithers, shows that antibody response to carbohydrate antigens is crucial in protection. He suggests that it is probably not necessary to use protein antigens in a vaccine: a number of the carbohydrate antigens should suffice. It will be more difficult to identify which carbohydrates are needed. But, once identified, it should be cheaper to make a vaccine from carbohydrates, which can be synthesised, than from proteins which have to be cloned.

John Newell

The dimensions of space-time

EINSTEIN taught us that instead of three dimensions of space and one of time we should think in terms of a four-dimensional space-time continuum. But how continuous is the continuum, and how closely does it fit the four-dimensional straightjacket?

Mathematical physicists have begun to ponder such points in the context of theories that space itself may "really" consist of 9 or 10 dimensions, all but three of which are hidden from us, and that some form of quantum "graininess" might apply to the fabric of space-time itself. Might the dimensionality of space-time actually be non-integer, differing slightly from the exact value of four? But the latest calculations by Berndt Müller and Andreas Schäfer, of the Johann Wolfgang Goethe University in Frankfurt, West Germany, bear out Einstein's view of the world.

The new calculations (*Physical Review*

Letters, vol 56, p 1215) jump off from an old standby among the tests of general relativity, the gradual change in the orbits of planets around our Sun, called the perihelion shift. The successful explanation of the perihelion shift of the orbit of Mercury was one of the first successes of Einstein's theory. The two researchers from Frankfurt have analysed the general problem of a perihelion shift in an arbitrary number of spatial dimensions—Einstein's equations can easily be generalised to any number of dimensions. They find that the predicted perihelion shift for Mercury only agrees with observations if the space dimensionality of our Universe is 3 ± 10^{-9} .

This might be enough to satisfy most theorists, but the researchers have also tackled the problem again in the context of quantum theory, this time generalising the Schrödinger equation, which describes the behaviour of the electron in the hydrogen atom, to an arbitrary number of dimensions.

Both approaches depend on the fact that observations show that the forces involved obey inverse square laws. The gravitational potential and the electric potential fall off with distance r as $1/r$, and it turns out that the form of this potential (which has to be differentiated to give the inverse square law of force) is precisely given by the rule that the potential falls off as r^{2-D} , where D is the number of space dimensions. In other words, if D differs from 3, then the potential differs from a precise $1/r$ law.

One of the early triumphs of quantum theory was that it explains a small shift in the position of features in the spectrum of hydrogen, called the Lamb shift. But the new calculations show that this agreement holds only if the quantum mechanical calculations are carried through in space with a dimensionality of $3 \pm 3.6 \times 10^{-11}$. This figure is so precise, say Müller and Schäfer, that it makes the dimensionality of space "the best measured, but probably least understood, dimensionless constant in physics".

Burrowing rodents a risk at dump sites

SMALL furry animals seem unlikely nuclear saboteurs. But, when low-level radioactive wastes are buried, the assumption is that the layer of soil above it will keep in the radioactivity. Now, a team of American researchers has found that small burrowing mammals breach the soil barrier and could help to spread contamination (*Journal of Applied Ecology*, vol 23, p 13).

W. J. Arthur, O. D. Markham and D. K. Halford, of the US Department of Energy, Radiological and Environmental Sciences Laboratory, Idaho, and C. R. Groves and B. L. Keller, of Idaho State University, measured the doses of radiation received by kangaroo rats and deer mice living in and near a dump in Idaho.

They found that rodents living in the disposal area received daily doses of between 4 micrograys and 418 milligrays—mostly as a result of exposure to buried activation and fission products, and not from radionuclides in or on the rodents' tissues. They put the variability of the

doses down to the fact that individuals encounter different types and amounts of radioactive materials depending on where they burrow. Animals in an adjacent site received significantly lower doses, up to 4 micrograys a day.

Since dumping began in 1952, about 3×10^{17} Becquerels of solid contaminated waste have been buried at the site. The wastes are covered with 0.6 metres of soil. Adding more soil, to a depth of 1.8 metres, does not seem to stop the burrowers reaching the contaminated parts.

The scientists estimate that 43 per cent of the deer mice and kangaroo rats in the area have contacted radioactive waste or contaminated soil. They suggest that once the animals have brought contaminated material to the surface, it is spread further afield by wind or water, or by the rodents themselves. Radionuclides could enter food chains via predators, and the burrows could act as drains for rainwater, hastening deterioration of waste containers. □

Did Neanderthal babies have bigger brains than ours?

Sarah Bunney

NEANDERTHALS have always been a puzzle. These robustly-built people lived in Europe and Western Asia from around 130 000 to 35 000 years ago. Since they were first discovered in the middle of the last century, anthropologists have not stopped arguing about them. Two of the latest bones of contention are the Neanderthal's curiously-shaped pubic bones at the front of the pelvis. These bones gave Neanderthal women extra large birth canals.

To one authority on these early people, Erik Trinkaus of the University of New Mexico, the commodious pelvis suggests that Neanderthal women carried their babies for 11 to 12 months and that the infants were better developed at birth. Trinkaus's idea, first proposed three years ago, became common myth in the absence of critical comment on it. But now, anthropologists are offering two alternative explanations for the Neanderthal's obstetrical peculiarities. Both discount the notion that Neanderthals had a gestation lasting three months longer than ours.

One of the new theories, proposed by Christopher Dean and Tim Bromage of University College, London (UCL) and Chris Stringer of the Natural History Museum, involves a three-year-old Neanderthal child from the Devil's Tower Cave on the Rock of Gibraltar. Their theory (to be published in the *American Journal of Physical Anthropology*) could be the basis of a radical new interpretation of Neanderthal growth and development. It could also revive the notion that Neanderthals are not close relatives of ours.

In Neanderthals of both sexes, the pubic bones are "stretched out" to enlarge the pelvic bowl (see figure). Trinkaus believes that this extra volume allowed a Neanderthal mother to give birth to a baby with a skull, and brain, about 20 per cent larger than our infants have at birth. Such babies would have been larger, more mature and more resilient than the human infant. In general, Trinkaus has found, Neanderthal children were more robust and better developed than modern children of the same age.

According to Trinkaus, this extended gestation developed among early representatives of *Homo sapiens* once their adult brains had reached the modern size range of 1200 to 1600 cubic centimetres (cm³). This critical development could have happened towards the end of the middle Pleistocene, after 200 000 years ago. Trinkaus admits, however, that a 12-month pregnancy would have made great metabolic demands on the mother carrying the baby and would have restricted her mobility.

Today's average person has a brain three times as big as that of an ape of equivalent build. Three-quarters of the development of a human brain takes place after

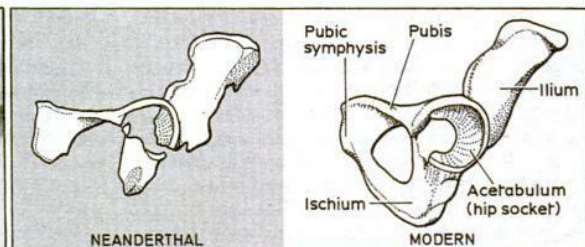
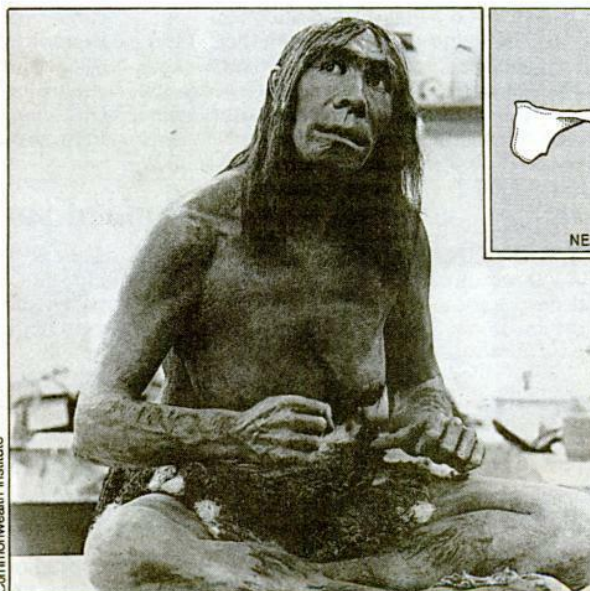
birth—the brain's capacity increases from about 400 to just under 1400 cm³. Both in the womb and after birth our brain grows faster than an ape's. During the infant's first 12 months, growth continues at the fetal rate, and by the end of the first year, the brain has more than doubled in size. After that, the rate of growth slows down. By the time we are 6 or 7 years old, our brain has almost reached the average adult size of about 1400 cm³.

In contrast, a chimpanzee's brain at birth, after eight months' gestation, is already half its adult size. To be born with brains that advanced, we would have to

immigrants to Europe and Asia from warmer parts of the world, probably Africa.

Whatever the evolutionary position of Neanderthals, there are anatomical grounds for arguing against Neanderthals having over-large birth canals and extended pregnancies, according to an American anthropologist, Karen Rosenberg, who has just completed her doctoral thesis at the University of Michigan.

Rosenberg bases her arguments on the premise that Neanderthals were short-statured heavy people with large heads relative to their height. So, she says, they gave birth to relatively large babies with large heads and needed correspondingly large birth canals to do so. Today, says Rosen-



Neanderthal peculiarities. From the midline to the hip joint, the pubic bones are longer and more slender than those of modern woman

berg, people with proportionately large heads, such as Eskimos and Mayans, though not as heavy as Neanderthals, also have longer pubic bones and wider birth canals than the modern average relative to their stature.

Rosenberg told *New Scientist* that she has found no anatomical evidence "to support Trinkaus's hypothesis that Neanderthal infants were born at a later stage in their development than modern humans". On the contrary, "Neanderthal infants at birth were about the same size relative to their mothers as are modern infants and were born at a similar stage of development. They probably required a similar degree of parental care as newborns of modern cultures". Thus, she concludes: "there is no reason to postulate a major reproductive or behavioural shift in the transition from Neanderthals to later humans."

Stringer and his colleagues at UCL agree that 9 months is the most plausible gestation for Neanderthals. Bob Martin, professor of physical anthropology at UCL, and others have found there is a close allometrical relationship between maternal weight and length of gestation among all primates. "There is never variation in the length of gestation within a species or between closely related species", Martin told *New Scientist*. So the maternal weights and gestation lengths of the great apes overlap those of modern humans. It is "highly unlikely", says Martin, that Neanderthals had pregnancies longer than ours.

But the British researchers argue with Rosenberg's explanations of why Neanderthals had large birth canals. They do not agree that Neanderthals were heavier for their stature than heavy-bodied modern people. Nor, says Stringer, were

have a gestation lasting 12 to 15 months—that is, if fetal development followed a normal modern human pattern. If we were still growing like apes, however, our gestation would have to be twice its normal length—18 to 20 months.

The Neanderthals, suggests Trinkaus, had a childbearing pattern similar to what people should have if evolution had followed a predictable path. But, this did not happen, and our stay in the womb has been greatly shortened.

Trinkaus believes that the abbreviated gestation evolved when fully modern people first emerged in Europe and Asia some 50 000 to 30 000 years ago. There would have been an evolutionary advantage, he says, in having a narrower pelvis and a shorter interval between births. Only at this point in human evolution, he holds, did people have the anatomical, social and cultural equipment necessary for protecting and nurturing very helpless babies and caring for them for an extended period.

Trinkaus is one of a number of palaeoanthropologists who contend that at least some of the Neanderthal groups in Europe and Asia may have evolved anatomically and culturally into fully modern people. Others, including Chris Stringer, take the line that Neanderthals were an evolutionary dead-end. They were replaced in the human story by modern-looking

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► Neanderthals heavier than the earliest modern humans of Europe, the Cro-Magnons.

Stringer and his colleagues are also concerned that Rosenberg does not fully take into account the Neanderthal's large adult brain, which was at least 10 per cent larger relative to body size than is normal for modern humans. The average was well over 1400 cm³; some large males even had brains exceeding 1700 cm³ in capacity.

Among other anatomical characteristics to consider, Stringer says, are the greater maturity of young children that Trinkaus has observed, and the very odd pubic bones. "There is a clear difference in pelvic form between Neanderthals and even the earliest modern humans", he told *New Scientist*. "And the two types existed side by side 50 000 years ago."

The British researchers think it unlikely that all these factors can be explained simply by allometry, as Rosenberg suggests. But can there be another explanation for the enlarged birth canals? The London scientists think there can. The Neanderthals, they say, could have had a different reproductive strategy from us, entailing even faster growth in the womb. Their babies could have been born after a standard 9 months' gestation with brains up to 20 per cent larger than modern newborn babies have—the size Trinkaus predicts after a 12-month gestation. They suggest that this accelerated growth may have been purely a Neanderthal adaptation or it may have a longer ancestry, perhaps as far back as *Homo erectus*, the supposed forerunner of *Homo sapiens*.

Dean and his colleagues' deliberations on Neanderthal childbearing are supported by new evidence from fossils of young Neanderthal children, in particular the child from the Devil's Tower Cave, dating from about 50 000 years ago. Dean and Bromage clarified that the child was three years old when it died by counting the incremental growth markings in the enamel on the surface of an unworn incisor tooth (*New Scientist*, 7 November 1985, p 26).

Previously, no one was sure whether the child was three or five years old when it died. Evidence from the temporal bone also suggests an age of three. But in other ways the child was more advanced than we would be at that age. Its brain was already about 1450 cm³ in capacity, "probably nearly 95 per cent of its adult size", says Martin. In modern humans, the brain does not reach this percentage until a child is about five years old. At least two other Neanderthal children, from Engis in Belgium and Pech de l'Azé in France, also had very large brains for their age. So, Stringer and his colleagues suggest that Neanderthals grew bigger brains before birth. A newborn baby with a brain approaching 500 cm³ would have a very large head indeed.

Accelerating brain growth before birth could have been the Neanderthal's way of using metabolic energy more efficiently, they suggest. This strategy could have been more economical for the mother than expending energy on nursing her baby for an extended time after birth. And the children would have been better equipped at an earlier age for life about them. □

A crop for all seasons

CASSAVA (manioc) is the staple food of 700 million people throughout the tropics. Its tuberous roots are a rich source of starch and are turned into flour, breads and tapioca. Such are cassava's remarkable physiological characteristics that crop breeders at the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, believe that they can produce a strain that will survive—and give a good yield—in the most drought-ridden parts of the world. It could play a major role in preventing the periodic famine that beleaguers parts of Africa and north-eastern Brazil.

The scientists at CIAT found that cassava is uniquely able to survive drought. Most plants begin to take measures to curtail their water loss only when the water in the soil is quite depleted. But cassava conserves water at all times, and once a crop is established, it is difficult to kill it merely by depriving it of water. This makes cassava a crucial staple in areas of sporadic, uncertain rainfall. On the other hand, the sensitivity to variations in the air humidity, could be a disadvantage in some conditions, for example when soil water is not a problem.

Cassava is able to conserve water so efficiently because its stomata, the pores on the surface of the leaves, are highly sensitive to changes in humidity. They close immediately humidity begins to fall. This prevents water vapour escaping through the pores by the process of transpiration at a time when supplies are dwindling. It also prevents the uptake of carbon dioxide, an essential ingredient for photosynthesis. To compensate, cassava shows a marked heliotropism; during periods of high humidity, especially early in the morning and late in the afternoon, the leaves move towards sunlight so maximising photosynthesis at a time when the potential for water loss is lowest.

Rapid closure of the stomata has a second disadvantage. During the hottest parts of the day, plants are kept cool by evaporation of the water vapour that normally exits through the pores. When the pores are closed, the leaves could overheat. Cassava, however, has a way of protecting itself from full force of the midday Sun. When it gets too hot, it droops its leaves, moving them out of direct sunlight. When the level of humidity rises, the plant recovers immediately and in two or three days the leaves assume their normal rate of photosynthesis.

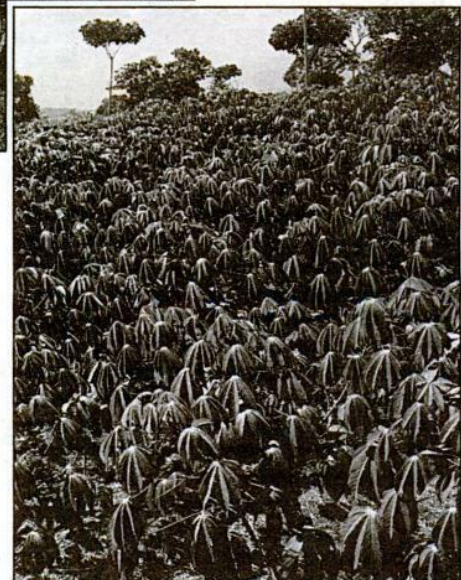
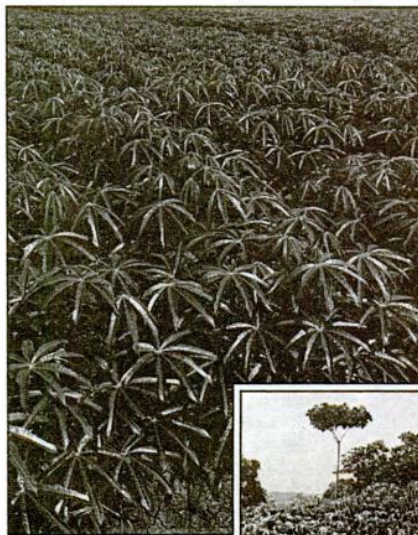
But, although all these mechanisms enable cassava to survive and make the most of a limited supply of water, they do not explain how the plant manages to give such a high yield under drought conditions.

The explanation lies in another unique

physiological response to water stress. When water is short, cassava stops producing new leaves and diverts its resources to its roots. So, although overall growth is drastically reduced, growth of the root—the important part to cassava eaters—remains stable. Cassava differs fundamentally from most other crop plants, which produce their carbohydrate source, the leaves, first, before converting the products of photosynthesis into fruits. Cassava produces leaves and roots at the same time, so both parts of the plant compete for the available

carbohydrate. For the best yield, there must be a delicate balance between leaf and root growth. Too much leaf, and there is not enough excess carbohydrate for root growth; too little leaf and photosynthesis is limited and all parts of the plant suffer.

Now the researchers at CIAT know how cassava tolerates drought, they are in a



In the cool of the morning, cassava holds up its leaves to catch the Sun (top); later they droop to avoid its fiercest, drying rays

position to help farmers by developing hardier and higher-yielding varieties. They are looking for varieties with the most sensitive stomata and efficient use of water for planting in the driest regions.

Yield can be improved further by cultivating cassava among other crops. Because cassava is more sensitive to air humidity than to the amount of water in the soil, it helps to grow it between rows of crops such as maize, which increase the humidity of the air around them. Trees have the same effect.

Once the crop breeders at CIAT have identified the most tolerant varieties, they will be able to provide a more stable staple for regions where famine is never too far away. □

TECHNOLOGY

Europe's new fighter flies out of trouble

DISAGREEMENT between Britain and West Germany about Europe's proposed new fighter aircraft (EFA) seems to be fading. Defence officials, who met in Munich last week, say that details of EFA's design will be settled by September and that the people to head the development of the fighter have been selected. The announcement comes shortly before a full-scale mock-up, demonstrating EFA's concept, goes on display at the Hanover Air Show next week.

EFA is to be designed and built by Britain, West Germany, Italy and Spain. Until last week's meeting, the partners in the venture could not agree on basic points, such as the aircraft's weight. A report published by the Western European Union (WEU) last month said: "the fighter aircraft project is not progressing as expected". The union provides an international forum for political discussions. Most members of NATO belong to the union.

The WEU's report put the blame for the fighter project's lack of progress on the British and West Germans for failing to agree on "design leadership, financing and production". The acrimony is mainly between these two countries because they will each contribute 33 per cent of the cost of the project. Italy will be responsible for 21 per cent and Spain for 13 per cent.

The disagreement about the aircraft's weight occurred, according to the WEU's report, because Britain wanted an aircraft capable of hitting more targets on the ground, and with a longer range. More equipment would be needed for both suggestions, and would add to the weight. Last week's meeting seems to have resolved the question of weight, as well as making some decisions about the equipment that EFA will carry. The plane, when empty, will weigh 9.75 tonnes. This decision reiterates one made last August by defence ministers when they gave the project the go-ahead. Details about the equipment agreement are not being released yet.

The main British company bidding for a share of the EFA project is British Aerospace. The company, working with German and Italian companies, has built an aircraft known as the Experimental Aircraft Programme (EAP). EAP will never fly as a combat plane, but it demonstrates many of the technologies that British Aerospace would like to see adopted for EFA. EAP, which was shown to the public for the first time last month, will make demonstration flights at the Farnborough Air Show in September.

Like the EFA project, the EAP is encountering difficulties. Although it was built in three years—a short time for such a plane—its first flight has been delayed. EAP was scheduled to take to the air this week, but staff at British Aerospace's factory in Warton have been on strike since the beginning of May.

However, on the same day that defence officials announced their agreement in Munich, British Aerospace decided to let managers take over the job of preparing the

Helen Gavaghan

EAP for flight. The company has also won extra funding from the Ministry of Defence to pay for test flights.

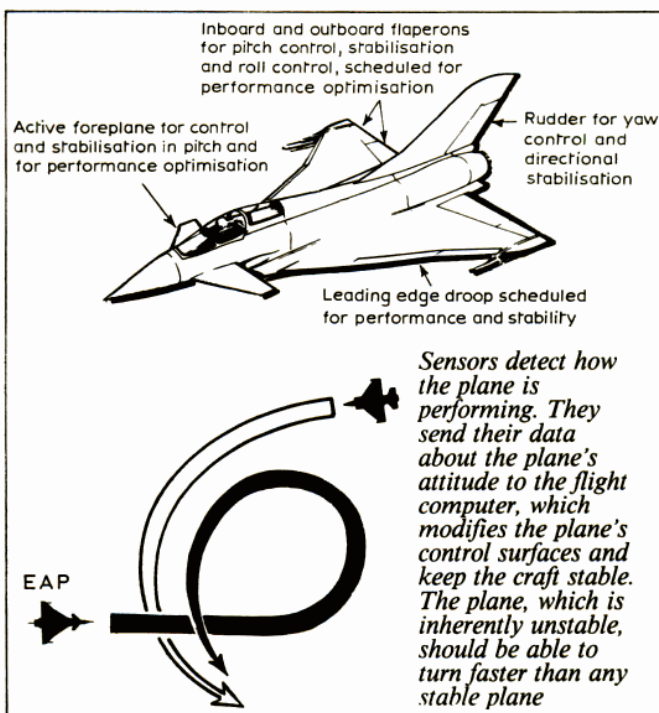
The most unusual aspect of the EAP is that, unlike any craft in service today, it is designed to be aerodynamically unstable. It is like the unsuccessful paper darts that plummeted to the floor rather than completing the flight to the front of the classroom. Instead of flying in a straight

The sensors feed this information to the flight computer which compares the pilot's instructions with what is achieved, and then commands the control surfaces to compensate for any differences. The sensors also detect unexpected gusts of wind buffeting the aircraft and again, the computer issues instructions to compensate for unexpected movements. The system responds to conditions within milliseconds.

John Vincent, project manager for the

EAP, says that a pilot needs about 0.2 seconds. British Aerospace has demonstrated that this technology works in a Jaguar aircraft converted to be 13 per cent unstable. The EAP is 15 per cent unstable. Vincent says that the speed of the computerised control system is what limits instability, but that his engineers believe that the EAP is very close to an optimum balance of instability and performance.

Besides instability and digital controls, the EAP has other new technologies. Many structural parts are made from carbon fibre. Vincent says that the way that British Aerospace's engineers "tailor" the



line, the EAP is always ready to turn, and a gust of wind can upset the way it moves.

The EAP is unstable because the weight vector is in front of the lift. British Aerospace's engineers achieved the imbalance by adding foreplanes, which look much like miniature wings, at the front of the aircraft.

EAP is one of several unstable fighters under development. Engineers in the US, for example, are working on the experimental X29, and the French company Dassault-Bréguet is working on a light combat aircraft known as Rafale. The Rafale is due to make a maiden flight soon.

The advantage of unstable aircraft is their agility. The pilot can turn the plane much more quickly than if it were stable. The disadvantage is that no pilot can fly such a plane without the help of a computerised control system, because no pilot can react quickly enough to compensate for such planes' inherent instability.

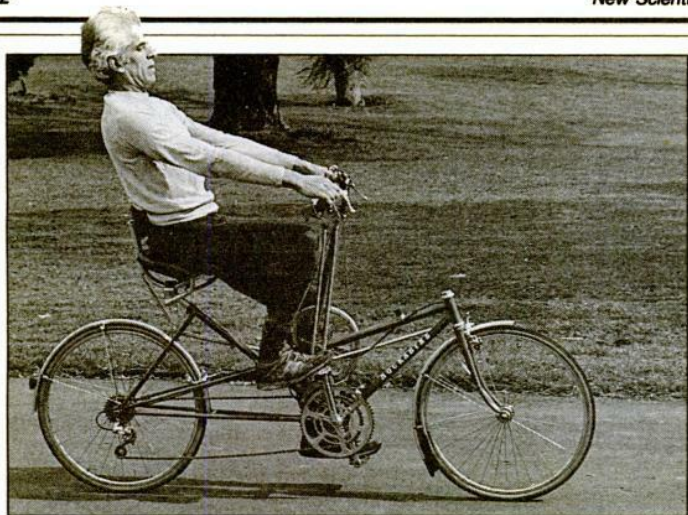
In the EAP, the pilot feeds instructions about the plane's course to a computer on board. The instructions are converted into action by the plane's electrohydraulic system, which moves the control surfaces on the wings and tail. Sensors detect pitch, yaw and roll and external sensors on the nose and wings detect the ambient wind.

carbon fibre sheet that make up the wings is of great interest to engineers in the US, who do not believe that the company has achieved what it claims. The idea is to lay down sheets of different sizes and with their fibres running in various directions so that the finished product, say a wing, is flexible where it needs to be and stiff in other parts.

Another production success for the EAP is the way that the bottom surface of the wing is bonded rather than bolted to internal struts. The EAP would have about 3000 bolts. Apart from the disadvantage of the bolts' weight, holes have to be laboriously drilled for each bolt, and each hole can provide a pathway through which fuel might leak.

In the EAP, instead of bolts, the bottom part of the wing is attached by a technique known as superplastic diffusion bonding. This technique also means that engineers do not have to put minute amount of packing between struts and wing surface to ensure that they fit flush.

Future developments for fighter aircraft include sending instructions around the plane through optical fibres, and developing a voice recognition system that can decipher what a pilot is saying, even when forces of 8g distort the voice. □



Push-Me-Pull-You

A NEW KIND of bicycle, known as Rockabike, was shown at the Festival of Mind, Body and Spirit last week. The bike puts the arms, shoulders, torso and hips to work as well as the legs. This extra force is added to the pedals to make the bicycle faster, more powerful and, paradoxically, less tiring to ride.

The handlebars of the bicycle are attached to an arm pivoted on the frame above the pedals. The cyclist rocks to and fro, pushing and pulling on the handlebars as if rowing. This movement is transferred to the pedals by a two-way chain and ratchet system. The seat is also pivoted, and the force from the hip movements while rocking is added to the drive mechanism.

The steering system was the most difficult problem encountered



by the inventor, Francis Green. For steering, the handlebars are connected to the front wheel by a system of levers. The brake levers are in their usual position, and the gear change for 14-speed derailleur gears are fitted to the handlebars as well.

The inspiration for Rockabike was a desire by Green to build a machine which would mimic the movements of a running animal. On an early prototype, Green had the cyclist face down as if on all fours, pedalling with both arms and legs. This proved unworkable and Green modified his attempt to turn people into a quadrupeds.

The handlebars on Rockabike move independently of the pedals allowing the cyclist to work them at different speeds. Long slow movements can be used for acceleration when starting off; shorter, pumping movements can help propel the bike up hill. The Rockabike costs £975. □

Leaping from track to track... by laser

IF YOU see the disc jockey doing impossible things with a compact disc record, it is probably because the player is a new machine just announced by Technics of Japan. The laser can pick out any part of a one-hour recording within 0.6 seconds.

In the machine, the optics and the laser are attached to a coil which moves along a guide rod between two bar magnets. Conventional players move the optics with a train of gears and are slower. The DJ can set a start point with an accuracy of better than 0.1 seconds, and move between tracks with a single player as quickly as with two conventional players.

The chassis of the laser is die cast from

heavy metal. Even the most clumsy DJ cannot knock the laser off its cue point and make the music start in the wrong place. Playing speed and musical pitch can be varied by 8 per cent up or down with a slider control. This lets a DJ alter the playing time of a record to fit an available slot, for instance at the end of a broadcast or before a commercial break. The pitch variation lets a DJ with a good musical ear match the last note of one piece of music with the first note of the next.

The oddest feature of all is the facility for "scratch play". On a conventional gramophone, "scratching" is done by moving the record by hand, backwards and forwards

under the pickup. It creates a stutter effect now heard on some pop records. The same technique cannot normally work with CD. The decoder, which converts the digital pulses into analogue music, relies on a stream of digital bits arriving at a constant speed of just over 4 million a second.

The Technics player "scratches" with a modified pause control. Normally, when the pause control of a CD player is pressed, the laser stops tracking across the disc and the sound mutes. In the new player, the laser stops tracking but the player does not mute. It repeats the same musical phrase, like an old-fashioned gramophone record stuck in the groove. □

Circular web helps arthritis sufferers

ARTHRITIS sufferers will shortly be offered a new type of hand exerciser that its inventor, Martin Greenfield, claims can be used to carry out more than 25 different exercises, far more than the mechanical devices or special putties that are usually used to exercise afflicted hands.

Greenfield's invention is called the Web. It consists of a rubber-covered metal hoop, "strung" with a rubber mesh into which someone's fingers can be inserted. The device looks rather like one of those rubber mats that keep clothes in place in a spin dryer.

The rubber mesh in the middle of the Web has a uniform elasticity. Greenfield has produced exercisers with different resistances: a stiffer model for athletes, such as boxers and golfers, who need to strengthen their hands, and a softer version for those who need to do hand exercises for medical reasons.

The Web, which will cost between £10

and £12 when it is in production, can be manhandled in a number of different ways to exercise different parts of a person's fingers and hands. Most of the exercises involve poking your fingers into the mesh and pressing against the rubber matrix by clenching your hand, making scissor movements with your fingers, or walking your fingers across the web.

Greenfield says: "The advantage of the Web is that you can do all these different exercises to prevent muscular imbalance (developing one set of muscles at the expense of others) and avoid the staleness that comes from repeating one movement over and over again."

Greenfield has demonstrated the web to the National Orthopaedic Hospital in London. A physiotherapist at the hospital said: "It is quite a useful little thing; it may have some useful applications." □



An exercise to strengthen the hands

Communication on the factory floor

B RITISH makers and users of factory automation equipment are trying to put themselves on the MAP; that is, the Manufacturing Automation Protocol, a set of standards for linking up computer-controlled factory machines. Many industrialists regard such standards as a vital element in extending the effectiveness of factory automation.

Some British companies now take MAP so seriously that they are prepared to spend £5.2 million on a large-scale demonstration of what the standard will enable manufacturers to do. In December, 50 organisations will take part in the demonstration, which will show lathes, robots, chemical processing equipment and associated office computers working together to produce products.

The organisations will have the backing of the Department of Trade and Industry. The pretend factory will be set up at an as yet unnamed exhibition centre and will sprawl over an area the size of two football pitches.

MAP and a complementary set of standards for design and engineering offices, known as Technical Office Protocol (TOP), are American inventions. General Motors began work on MAP in 1979 and encouraged other manufacturers and standard setting bodies to get involved in the development work.

MAP is a set of rules that governs the conversations that take place when computers controlling different elements in a manufacturing process communicate with one another over a local network. The network might span a factory or group of factory buildings. General Motors claims to have more than 40 000 systems controlling equipment on the floors of its factories, but only one in seven can pass data to machines outside the process it is involved in.

This incompatibility means that General Motors and other large manufacturers find it difficult to integrate their manufacturing processes. The lack of factory standards also means that manufacturers cannot mix equipment from different suppliers to create more efficient and cheaper automated lines. General Motors believes that MAP will enable it to cut the cost of automation and reduce stocks of raw materials and work-in-progress, so cutting the cost of making a vehicle. Less material will be needed because MAP should enable the company to plan and control production better.

TOP, Boeing's brainchild, is designed to link the computers used by draughtsmen, engineers and production managers. The standard has been designed to link with MAP so that data can flow to and from systems on the shop floor.

The British MAP demonstration will have two networks working with MAP standards and one coupling system working under TOP standards. It will also include links with factories elsewhere in Britain and America.

In America some 300 manufacturers have said that they plan to use products which conform to MAP. They include companies such as Eastman Kodak, DuPont, and McDonnell Douglas. In



In search of a compatible link between the office and factory

Britain, support for the idea has come from Unilever, Jaguar Cars and Mars.

Unilever, the soap company, plans to set up a MAP pilot scheme to link systems that control and monitor its process plant. At present, data about the composition of products at different stages in the production process has to be sent back to laboratories for quality analysis on paper.

The company would like to link the laboratories directly to sensors on the shop floor. Unilever also wants to draw on production information provided by plant controllers by hooking administrative computers to them. Without standard communications this is impossible.

Eventually, Unilever envisages transmitting formulations for its detergents and other products directly to the machines that make them in the process plant. "We have been talking about something like MAP for years," says Vic Gregory, Unilever's manager of corporate projects, "but only General Motors is big enough to do something about it."

One drawback to MAP, apart from the fact that the fully fledged version will not be ready for another two years, is its cost. At present it costs some \$3 000 to connect a computer to a MAP network, though the price will come down as the circuits are switched from printed circuit boards to chips. Once volume production of chips is underway, in a few years time, the cost of a connection should come down to around \$100, putting MAP within reach of smaller manufacturing companies.

Although MAP has been pushed by the customers of computer and machine tool companies rather than the other way round, John Butcher is keen that British equipment suppliers latch onto MAP as quickly as possible. About 80 per cent of the software and hardware that will be used in the December demonstration is American and has already been used in similar events in the US. "There is no reason to be worried (that American companies are ahead of their British counterparts)," says Butcher, "but we have every right to urge British companies to take advantage of this opportunity." □

Television indecision

THE INTERNATIONAL Radio Consultative Committee (CCIR) met last week in Dubrovnik, Yugoslavia, to make a decision about a world standard for high definition television (HDTV). In the event, the CCIR decided that it is too early to make a final decision.

The CCIR can only set world standards at its plenary sessions. These are held every four years and a session fell due in 1986. It has decided to ask a committee headed by Professor Kriboshev from the Soviet Union to make a full study of HDTV technology. Instead of setting a standard, the CCIR will then take a final decision at the next plenary session in May 1990.

Japan and the US have already made clear that they have no intention of waiting. The Japanese electronics and broadcast industry, backed by CBS in the US, wants the world to adopt a 1125 line system based on 60 pictures a second.

The European broadcasters do not like the 60-Hertz standard because they fear it is not compatible with existing standards in Europe, which will all rely on 50 pictures a second (*New Scientist* 8 May 1986, p 36). The snag is that the European electronics industry has no alternative technology to offer. □

Nuclear protection

B RITAIN'S Royal Air Force may equip fighter pilots with goggles that turn opaque in a fraction of a second. The idea is to protect pilot's eyes from the flash of a nuclear explosion.

Until recently, the only protection the pilots have had has been to wear a patch over one eye. After the flash, the pilot tears off the patch, and keeps flying with his good eye.

A ceramic material called PLZT is making this heroic procedure obsolete. It is a polycrystalline structure of lead lanthanum zirconate titanate, a material with electro-optical properties. PLZT is normally transparent. But a strong electrical field will align the light-carrying pathways of the crystals along the field. To someone looking at right angles to the direction of charge, the material appears opaque.

The Sandia company in the US already makes visors from PLZT for bomber crews. A light sensor detects the beginning of the flash, and triggers a pulse of up to 1000 volts across the crew's visors.

PLZT has a very high resistance, so hardly any current flows. The visors darken in about one thousandth of a second.

The British company Plessey has developed PLZT goggles that fit under a standard flying helmet. Plessey's engineers demonstrate the goggles with a photographic flashgun. The observer is aware of the flash, but when the goggles turn clear again, in less than a second, vision is normal. □

Sony's standard search

COMPACT DISCS storing 600 megabytes of data (CD ROM) instead of an hour of music will be a consumer product by the end of the year. Sony this week started pressing CD ROMs at its factory in Terre Haute, Indiana in the US.

The stumbling block to the progress of CD ROM so far has been industry agreement on how a home computer will search through the data stored on a CD ROM. In an effort to create a de facto standard Sony has signed a joint venture deal with a software company KnowledgeSet of Monterey, California. The joint venture is called Publishers Data Service Corporation. Sony's factory in Indiana will put the publisher's data on to compact disc.

KnowledgeSet will provide a retrieval program called KRS (Knowledge Retrieval System) so that a home or business computer can search through the data on the disc. The joint venture promises to turn data into a CD ROM ready for sale within four weeks. □



Rules for scales

CHUNG-YANG LEE of Taiwan is patenting (2 163 591) an all-mechanical aid to musicians. The idea is to help students learn their scales.

A ruler is marked like a piano keyboard. Along the top is a row of lopsided pointers. For the key of C all the pointers are parallel. To select another key, the student moves a slider along the rule and the pointers turn to tell which notes of the scale must be played sharp or flat. The ruler then becomes a pictorial guide to the black and white notes which make up the specified key. □

Patent Office loses business

THE ANNUAL report from the Comptroller of the British Patent Office shows that the office is losing more and more of its best customers. Instead of filing for patents in Britain, companies from the US, Japan and West Germany are lodging European applications through the European Patent Office in Munich.

This switch from Britain to Europe is exactly what people in Britain predicted 10 years ago when the EEC decided that Munich should be the site of the European Patent Office. The switch also shows what could happen if Britain loses its bid to be the site of the proposed European Trademarks Office.

The Comptroller notes that British inventiveness continues at a high level, with more than 60 per cent of all British applications being made by British residents. But he also notes an 18 per cent drop on patent applications from companies in the US, with Japan down by 9 per cent and the German Federal Republic down by 8 per cent. The Comptroller acknowledges that these three countries are his "main customers from abroad".

But the drop in filings means a substantial loss of earnings for Britain. This money now goes to the Continent. Patent applications at the European Patent Office continue to rise, and now hit nearly 40 000 a year.

The Comptroller's report shows how trends in invention follow newspaper headlines. Many firms have applied for patents on ways of removing the AIDS virus from blood products. Others have concentrated on cleaning the waste gases produced by coal and oil-fired burners to limit acid rain. Several inventors have proposed ways of replacing old-fashioned sewers, without digging them up. And, last year, there was a boom in new ways of making buildings safe against burglary. □



Obscuring patents

WHILE BRITAIN tries to make the patent system more friendly, India unwittingly provides an object lesson in how not to do it.

The Indian government publishes an official gazette which lists new patents. As an aid to searchers it includes a synopsis of each new invention.

Recently published Indian patent 157418 claims "an opto-mechanical-cum-electric device for measuring and displaying fibrous material length and optical thickness parameters". That is just the title. The synopsis runs to more than 1250 words, in a single sentence. □

Government lobbies for Trademark Office

THE ABOLITION of the Greater London Council (GLC) has had an unforeseen result. The government has had to take sole charge of a bid to persuade the EEC that London is the best site for a Trademarks Office which would serve the whole Common Market. The first bid, which was made four years ago, was a joint venture with the GLC. John Biffen, then Secretary of State for Trade and Industry, and Illyd Harrington, then Deputy Leader of the GLC, published a brochure praising London as the ideal location. It was full of now outdated, not to say embarrassing, references to the GLC and its leaders. So now the government has had to bring out a second brochure.

The Department of Trade and Industry is offering a choice of four sites. The office could be a new block to be built at St Katherine's Dock, an existing building in Cockspur Street, near Trafalgar Square, or new buildings in Harrow, north-west London, or Croydon.

"We do not as yet provide a home for any permanent community institution," says Geoffrey Pattie, Minister of State for Industry and Information Technology. "London is in every way the ideal choice".

West Germany, however, thinks differently. It would like to see the office in Munich, along with the European Patents Office. □



Overcoming carelessness

EVERYONE loses their door or car key once in a while. Anyone who is wise enough to carry a spare with them all the time has usually lost it by the time it is needed.

Tomoyoshi Miriyama, from Japan, says in European patent application 170 762 that the simple answer is to make a narrow key and build it into a pen. Fortunately, it is easy to make a narrow key, because the widest part is usually an enlarged handle designed to give turning power.

The mini spare is fitted to the top of the pen, and is hidden by a conventional cap. It is mounted on a pivot so that it can be turned at right angles to the pen body. This makes the pen body a lever, and gives some extra torque when turning the key in the lock. □

A safer way to take a baby's temperature

LAMBDA ELECTRONICS, from Hong Kong, has filed a British patent application (2 163 855) on a new idea for making it easier to take a baby's temperature.

Understandably, parents worry about using a delicate glass bulb thermometer, and the alternative, a heat sensitive strip which measures skin temperature, is inaccurate.

Lambda's idea is to use a "dummy" with an electronic sensor and liquid crystal readout. The dummy is of conventional shape, except that the teat has a solid tip filled with silicone

rubber in which a heat sensitive transistor is embedded. The sensor is flush with the surface so that when the baby sucks the teat, its tongue touches the sensor. This gives a temperature reading which corresponds to, although it does not necessarily equal, the baby's blood temperature.

The sensor connects with a calculator chip and a liquid crystal display which gives a direct readout of the calculated temperature. The readout is re-set, like the memory of a calculator, by pushing a "memory clear" button. □

How to make a million

TRADEMARK law has forced Apple to add an acknowledgement to McIntosh, a hi-fi company, in all its advertising. It was only after Apple had hit on the name Macintosh for its well-known personal computer, that it found to its horror that the mark had already been registered by McIntosh Laboratory of New York.

On the face of things, McIntosh's legal rights looked slim. McIntosh makes amplifiers, not computers; its trademark does not cover computers.

Also under British law no one can claim exclusive right to a well-known surname, so McIntosh had to disclaim rights to the exclusive use of the word McIntosh.

Nevertheless, lawyers for McIntosh Laboratory persuaded Apple that it would be cheaper to pay a rumoured \$1 million than fight the case in court and delay launch of the Macintosh computer.

At first, Apple's adverts simply referred to the trademark as used under licence, with no mention of the hi-fi company. Now McIntosh has tightened the screw and insisted that Apple should acknowledge them by name in every advert that it prints for the Macintosh computer. □

Patent information

Copies of patents, which contain fuller details and the addresses of inventors, are available from science reference libraries around Britain. For details of free public access and

purchase price, contact the London Patent Office and Science Reference Library at 25 Southampton Buildings, London WC2A 1AY (Tel 01-405 8721).

Barry Fox

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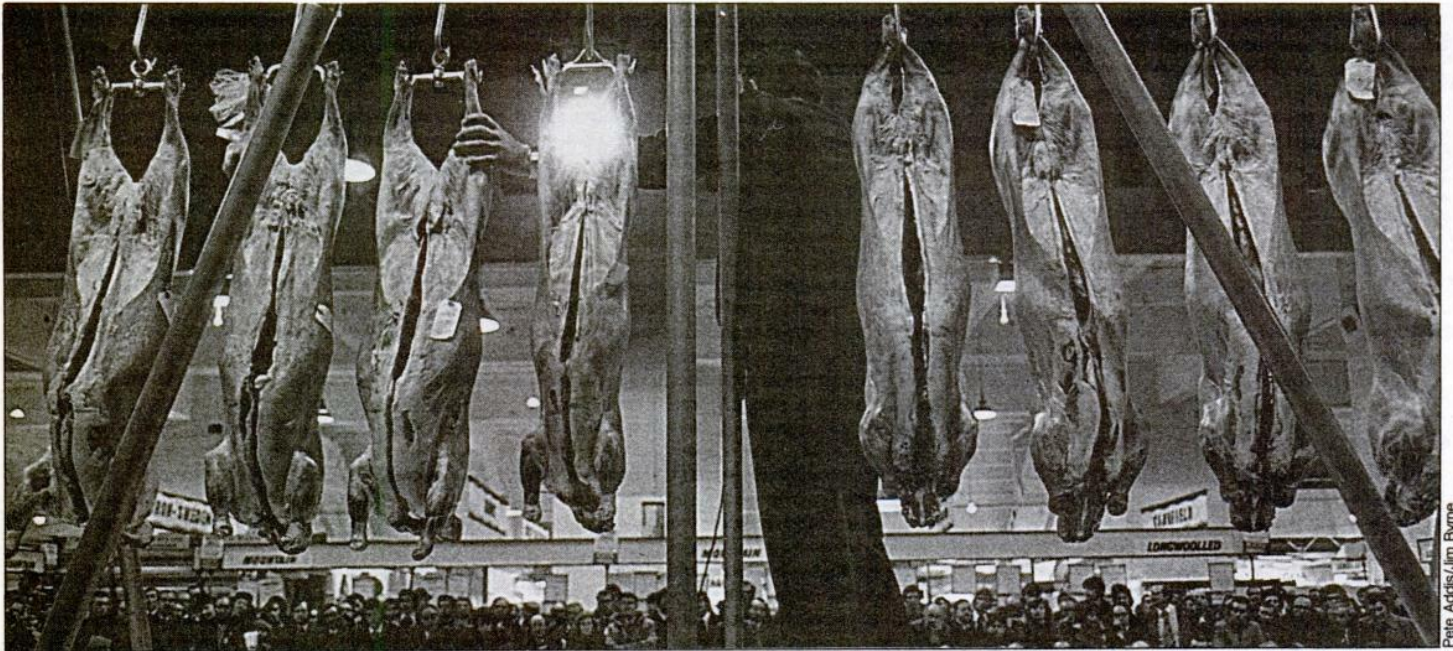
Send to SMART Office, Department of Trade and Industry, Room 204, Ashdown House,
123 Victoria Street, London SW1E 6RB.

**INNOVATION
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The tender touch of rigor mortis

Like all muscle, meat relaxes best after contraction. Physiologists are now investigating what happens during the biggest contraction of all

Monica Winstanley

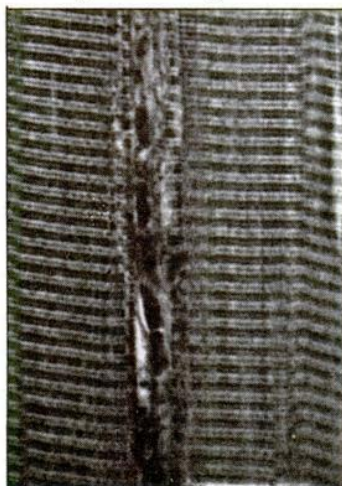


Pete Addis/Jim Byrne

READERS of detective novels are familiar enough with rigor mortis. Its effects on muscles are even better known to people who eat meat. The tenderness of a pork chop has a lot to do with what happens to a pig's carcass after slaughter: if the meat is chilled too rapidly, before rigor mortis sets in, for example, the pork chop will toughen irreversibly.

Scientists at the Institute of Food Research at Bristol are investigating the factors that influence the rate at which rigor sets in. These factors affect the meat's tenderness and its ability to hold water, which is related to its juiciness. The researchers, led by Robin Jeacocke, want to answer several questions about rigor mortis: why its onset is relatively slow, when it ought to occur rapidly as soon as the cell's source of energy is depleted; why it occurs gradually and not suddenly; and why its onset is paradoxically more rapid at low temperatures. The last question is particularly relevant to the way in which we store carcasses and prepare them for consumption. Rapid chilling, to comply with regulations in slaughterhouses, can conflict with the demand for tender meat.

Rigor mortis is an increase in the stiffness of muscles. It starts between 1 and 24 hours after death (depending on the species) and gradually develops over a period of 2 to 3 hours. Until rigor mortis sets in, it is still possible to extend the muscles and an electrical current can stimulate them to contract for some time after death.



Cold-shortening: muscle that has been rapidly chilled before rigor mortis (right) contracts more than normal muscle (left)

The onset of rigor is analogous with a machine "grinding to a halt" when it runs out of fuel. The stiffness associated with rigor mortis arises because muscle filaments lock permanently into the contracted position. In that state, connections, called cross-bridges, form between the filaments of protein (actin and myosin) that make up striated muscle. (Striated, or voluntary muscle, is the kind of muscle that we eat as meat, as opposed to smooth or involuntary muscle such as that making up the intestinal wall.) Jeacocke found that the muscle contracts immediately before the natural onset of rigor. The muscle then becomes locked into the contraction. This is a predictable point for the chain of events to cease, as it takes energy for the cell to release the connections between the muscle filaments, which would allow the cell to relax.

The cell's "currency" for energy is adenosine triphosphate (ATP). In the normal living muscle cell, the concentration of

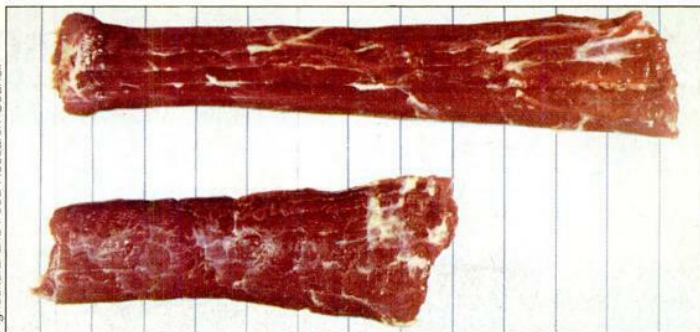
ATP is about 5 millimoles per litre. Experiments in the laboratory show that the cell needs a level of less than 0.1 millimoles per litre of ATP in order to release the connections between muscle filaments that form during contraction. This suggests that, in a carcass, muscles should remain relaxed and extensible until the level of ATP falls below this very low value, and that after their last contraction, which would take the level of ATP well below this, they should rapidly enter rigor mortis. What we actually see is a gradual increase in muscle stiffness, however.

Agricultural Research Council

Jeacocke has shown that this anomaly arises because different muscle fibres behave in different ways. He found that, whereas stiffness may take over an hour to develop in a whole mammalian muscle, small bundles of muscle fibres reach their maximum stiffness within about 30 to 40 minutes, and isolated individual fibres may stiffen within about 2 minutes. Though individual fibres go rapidly into rigor mortis, they do so at different times after death, so that the muscle as a whole enters rigor slowly.

The time that rigor mortis takes to set in varies according to temperature. To some extent, the rate of onset follows the general rule for chemical reactions—the lower the temperature, the slower the reaction. But there are anomalies. Between 38° C and 25° C, a decrease of 10° C almost halves the rate at which rigor sets in. At lower temperatures, however, rigor sets in more quickly than it does at some higher temperatures. At 2° C, for example, rigor sets in faster than it does at 15° C and at about the same rate as it does at 22° C.

Meat scientists are particularly interested in the influence of temperature because carcasses are normally refrigerated as



When meat cools down, it can get tough. The cold-shortened meat (below) started off at a similar length to the piece above

before meat leaves a slaughterhouse, the deep tissues of a carcass must be cooler than 7° C. To achieve this within 24 hours requires very rapid cooling.

Unfortunately, rapid chilling of carcasses before the meat has entered rigor produces extremely tough meat—a phenomenon known in the meat trade as “cold shortening”. As its name implies, cold shortening involves muscle contraction. Muscles from a freshly slaughtered carcass can shorten to less than half their resting length if they are cooled rapidly to below 10° C. Even when muscles remain fixed to the skeleton at both ends you can see zones of marked cold shortening, with stretching elsewhere.

Cold shortening uses up energy, so it accelerates the onset of rigor mortis. This explains why rigor sets in early at lower

soon as possible after slaughter. There are three reasons for this. First, rapid removal of body heat slows the growth of the bacteria that inevitably contaminate the surface of the meat during slaughter and preparation of the carcass. Secondly, lowering the temperature of the carcass's surface reduces evaporation and the subsequent loss of weight. Thirdly, the regulations of the European Economic Community stipulate that,

1: A shocking way to treat meat

PEOPLE have known for centuries that storing meat makes it more tender. This process is called “hanging the carcass”, a rather misleading term because the meat does not need to remain on the bones and will become more tender just as well if boned-out in vacuum packs. A better term is “conditioning”.

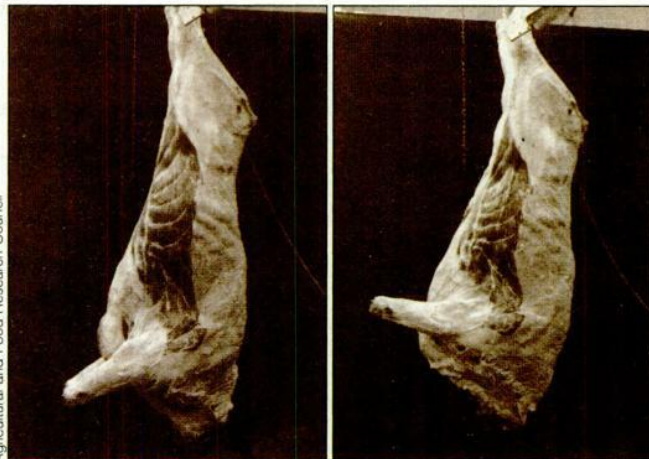
Conditioning occurs as a result of the breakdown of proteins in muscle. At rigor, you cannot extend the muscle, but after conditioning you can stretch it. In contrast to muscles before they enter rigor, such stretching is not reversible. If you look at conditioned meat under a light microscope you can see fractures across the muscle fibres. Under the electron microscope, it is possible to see degradation of the Z lines

—transverse structures across the muscle fibres which separate adjacent contractile units. This change is associated with increasing tenderisation of the meat. Scientists have shown, in laboratory experiments, that calpain, an enzyme activated by calcium, degrades the Z lines. This enzyme, which breaks down proteins, probably influences how tender the meat is.

The breakdown of connective tissue also has a part to play in conditioning. The enzymes implicated include cathepsins which are usually safely contained in cellular vesicles—tiny membrane-bound sacs—called lysosomes. These vesicles break down and release their contents only after the cell's death. It seems likely that as the meat becomes more acidic, these enzymes become active and break down proteins in the muscle.

Temperature determines the rate of conditioning. The meat industry usually maintains storerooms at about 1° C. This temperature slows both bacterial growth and the rate of conditioning.

Scientists are also exploring the use of electrical stimulation to accelerate conditioning. The aim of this method is to accelerate rigor mortis by electrically induced muscular contractions. This means that slaughterhouses can cool the carcass more rapidly after the animal's death, without

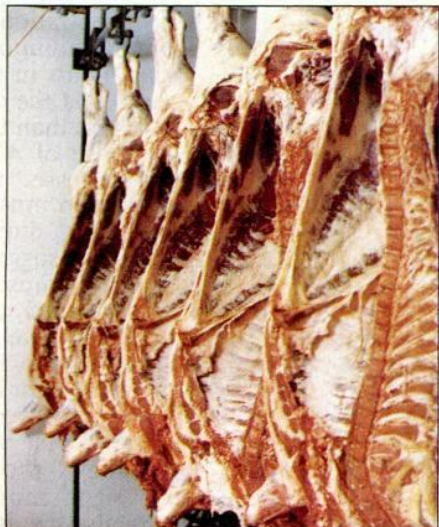


Electrical stimulation (right) may make meat more tender

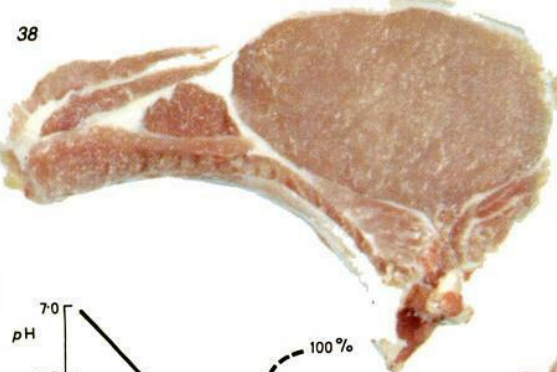
the risk of toughening.

Commercial systems using electrical stimulation for beef and lamb now operate in many countries, including Britain. But does electrical stimulation itself make the meat more tender? There is evidence that it causes muscle fibres to fragment, a process that may increase tenderness.

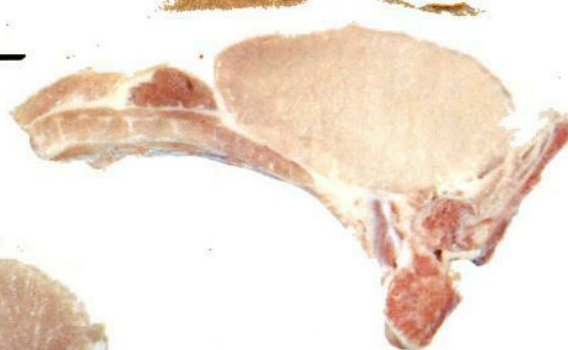
Electrical stimulation also accelerates the physiological changes that occur after death, so we might expect it to speed up the action of the enzymes responsible for natural tenderisation. The acidification that occurs after death may play a role in this: electrical stimulation accelerates glycolysis after death in a similar way to that in which stress-sensitive pigs produce pale, soft and exudative meat. However, electrical stimulation does not cause the quality of beef and lamb to deteriorate in the same way. □



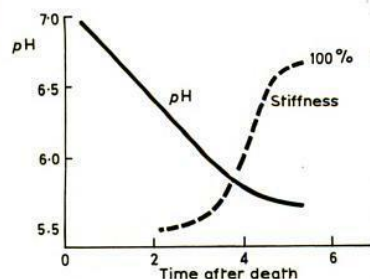
Beef needs conditioning for about 12 days



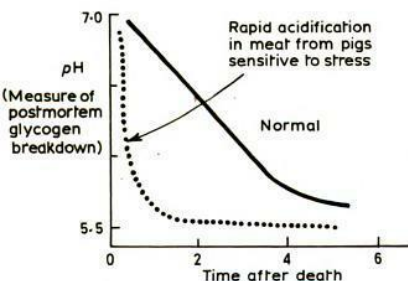
Dark, firm and dry meat (left) results if the pig is exhausted at slaughter. Compare with normal meat (below)



Pale, soft and exudative meat (above), which gives out fluid called drip, comes from pigs that are sensitive to stress



Normally, the pH of the muscle falls to around 5.7 within about 5 hours of death. In pigs that are sensitive to stress (below), this acidification occurs rapidly, giving rise to poor-quality meat



temperatures. But we cannot explain other features of cold shortening so easily. First, muscles cold shorten only before rigor has set in. Secondly, not all muscles cold shorten. Of those that do, only a minority of the fibres actively contract. The remainder passively fold up inside the shortened muscle.

Another factor that influences the onset of rigor mortis in some breeds, making the story even more complex, is how sensitive the animal is to stress. Some breeds of pig differ in their sensitivity to stressful events, such as travelling and mixing with other animals. If sensitive animals experience stress before they are slaughtered, the result is poor-quality pork.

In normal animals, the pH of the muscle falls from about 7.2 at death to between 5.5 and 5.8 about six hours later. This acidification occurs as the muscle breaks down its stocks of the carbohydrate glycogen and converts it into lactic acid to provide energy. Meat from pigs under stress, however, becomes acid abnormally quickly—within about an hour. This rapid acidification in a warm carcass denatures some of

the muscle's proteins and increases the normal postmortem shrinkage of muscle fibres. The poor-quality meat that results is characteristically pale, soft and exudative—known in the meat trade as PSE. PSE meat has a reduced capacity to hold water, and exudes a fluid called "drip".

If the pig is exhausted at slaughter, its muscles are depleted of glycogen. Meat from such animals is characteristically dark, firm and dry (DFD). Compared with normal meat, this has poor flavour, increased capacity to hold water, and does not keep well. Interestingly, the DFD condition also occurs in beef, particularly from bulls. Again, the lack of glycogen in the animal's muscles results from its behaviour before slaughter. Bulls that are more active and socially dominant within a group are more likely to produce DFD meat than others.

Calcium keeps a tight grip on muscle

These different observations of how muscle behaves after death, and in particular of what affects the onset of rigor mortis, present a complex picture. We can greatly clarify what is happening by looking at how calcium ions regulate events in muscle. In the living muscle cell, calcium ions mediate the control of contraction. They also regulate the breakdown of stored glycogen to replenish adenosine triphosphate (ATP). Calcium ions can therefore balance the muscle's activity with the supply of energy.

So far, we have considered the effects of lowered levels of ATP solely in terms of how this depletion directly influences the way in which muscles contract. Yet the lack of ATP has wider implications, both for the regulation of metabolism as

2: The stiff test that crime-writers fail

THE SLANG term "stiff" may seem rather callous, but it is an accurate description of one event that occurs after death. Many people, especially crime-writers and police officers, seem to have a touching faith in the ability of doctors to estimate the time of death from rigor mortis. However, the presence of stiffness is less reliable as an indicator of the time of death than the temperature of the body's core.

Standard forensic textbooks perpetuated this over-optimistic view of rigor mortis until quite recently. A typical quotation would be that "rigor takes 12 hours to come on, lasts for 12 hours and takes another 12 hours to pass off". All that is consistent in this statement is that it is consistently wrong!

Like almost all the events that occur in the body after death, rigor depends on temperature. The reason is that the rates of the complex physicochemical changes that lead to stiffening of muscle are themselves limited by molecular activity. In "average"

environmental conditions—though what people consider as average varies widely from Aberdeen to Abadan—rigor starts to set in within 1 to 6 hours after death and commonly spreads to all muscles within 4 to 10 hours.

However, there are wide variations. Every forensic pathologist has anecdotes of extremely rapid or long-delayed rigor mortis. In general, warm conditions accelerate rigor. In the tropics or an artificially heated environment, the body may be completely stiff within three hours. Conversely, cold may completely inhibit the muscle from stiffening, provided that the tissues do not freeze solid. I have seen a body left in the snow which was completely flaccid one week after death. Within a few hours of removal to a relatively warm mortuary, however, full rigor developed. Infants and feeble old people may develop only weak or even undetectable rigor.

The duration of rigor is usually related to the speed of its onset. Those corpses that stiffen rapidly tend to become pliable after

a shorter interval. Again, this characteristic usually depends on temperature, as the flaccidity that follows rigor occurs as the muscle enters the earliest stages of decomposition.

Pathologists have argued for years over the sequence in which rigor affects different parts of the body. The old dogma held that it starts first in the jaw and eyelids, then spreads down to the face, arm, hands, abdomen, thighs and then feet. However, some pathologists have pointed out that the size of the muscle mass determines the spread. As a result, rigor is apparent earlier in places such as the face than in the shoulder.

All muscular tissues develop rigor mortis, not just the large skeletal muscles. In the skin, the tiny muscles attached to each hair follicle often shorten after death, causing the appearance of gooseflesh. This effect may be one explanation for the persistent myth that the beard continues to grow after death.

The heart muscle also goes into rigor. Pathologists have to be aware of this, so

a whole and for the control of muscle contraction. Indeed, a central underlying theme emerges, involving the calcium ion.

In a resting muscle cell, the mechanism that initiates contraction stays switched off because the concentration of free calcium ions in the cytoplasm is low—less than 10^{-7} moles per litre. The cell maintains this extremely low concentration by continually removing calcium ions from the cytoplasm into the interior of a series of closed membranes within the muscle cell. These membranes are called the sarcoplasmic reticulum. The calcium moves into the channels enclosed by the sarcoplasmic reticulum as a result of the action of “pumps”—enzymes situated in the membrane—which require energy in order to operate. So the cell needs to expend energy all the time just in order to keep itself in a relaxed state of rest.

When nerves tell the muscle to contract, the sarcoplasmic reticulum becomes permeable to calcium ions, releasing a flood of calcium ions free into the cytoplasm. The concentration of calcium ions in the cytoplasm rises to more than 10^{-5} moles, which activates contraction. The calcium ions bind to the filament containing actin, causing structural changes which allow the myosin and actin to interact.

What happens to this control system after death? We can assume that as levels of ATP fall, the energy-dependent pumps of the sarcoplasmic reticulum become less effective. As a result, the gradient of calcium ions across the membrane—a low level of calcium ions in the cytoplasm and a high level within the sarcoplasmic reticulum—which the pumps usually maintain, would “push” calcium ions back into the cytoplasm. The higher level of calcium ions would trigger the contraction associated with the development of rigor, which, by further increasing the breakdown of ATP, would then mop up any ATP that remained.

Jeacocke used Arsenazo III, a dye sensitive to calcium, to observe changes in the levels of calcium ions. He showed that the concentration increases greatly at the onset of rigor mortis. There is a similar though smaller increase during cold shortening, presumably because calcium pumps are less efficient at lower temperatures.

Can the role of calcium explain why different muscle fibres enter rigor mortis at different times? One explanation for this heterogeneity is that different types of fibres have different ways of replenishing their energy supplies. They would run out of fuel for resynthesising ATP at different times, and so become depleted of ATP at different intervals after death.

There is some evidence to support this hypothesis. But depletion of ATP cannot adequately explain differences between fibres in the susceptibility to cold shortening, which occurs while the fibres still have plenty of ATP.

An alternative and attractive hypothesis, based on the role of calcium, accounts for the different responses in cells both rich in energy and depleted of it. For rigor mortis, the hypothesis is that the final contraction, leading to stiffness, results from a leakage of calcium ions into the cytoplasm as the pumps of the sarcoplasmic reticulum fail. Fibres enter rigor at different times after death because their systems for pumping calcium ions differ in efficiency, and some can withstand the decline of ATP better than others. Some studies of muscle physiology support this idea. Striated muscle has two types of fibre—“slow twitch” and “fast twitch”. The slow fibres contract slowly and rely on oxygen to fuel the release of energy. The fast fibres contract quickly and gain their energy by breaking down glycogen. Physiologists have shown that the systems for controlling the flow of ions across the sarcoplasmic reticulum are less well developed in “slow twitch” muscles than in “fast twitch” muscles. This would also explain why muscles rich in “slow twitch” fibres are much more susceptible to cold shortening than those rich in “fast twitch” fibres.

Death and tenderisation

The theory also holds good as an explanation of why pigs that are sensitive to stress produce meat that is pale, soft and exudative. In these animals, direct measurements have revealed elevated levels of calcium ions in their cytoplasm during rapid glycolysis; this calcium, we suggest, stimulates the excessively rapid glycolysis.

Thus the concentration of calcium ions appears to determine several changes after death that influence the quality of meat. Indeed, calcium almost certainly continues its influence after the onset of rigor mortis. Scientists investigating the enzymes already present in the muscle, which are responsible for the natural tenderising or conditioning of meat after death (Box 1) have identified a protease that is apparently responsible for tenderisation—and, yes, it depends on calcium ions for its activity. □

Monica Winstanley is head of the information section at the Agricultural and Food Research Council's Institute of Food Research at Langford near Bristol.

that they do not misinterpret the hard, contracted left ventricle (heart chamber) as evidence of high blood pressure.

In the eye, rigor in the muscle of the iris constricts the pupil and this may be very unequal in each eye. Because of these changes, as well as the frequently asymmetric dilation at the time of death, the size of the pupils is of no diagnostic significance—another blow to the Sherlock Holmes' school of detection.

Thus the practical uses of rigor in forensic pathology are limited. Used in conjunction with body temperature, we can generalise that if a body is warm and stiff, it has probably been dead between 4 and 10 hours in the so-called “average” environment. If the body is cold and stiff, then death may well have occurred between 10 and 30 hours previously. However, pathologists cannot be dogmatic about the time of death based on this very variable parameter, and an alibi which rested on such evidence would be very shaky indeed.

Very occasionally, rigor may be present in a pattern which is incompatible with the posture of the body when it is discovered. For example, a corpse might be found lying

on its back with one arm stuck up in the air in a “Nazi salute”. This would almost certainly indicate that the body had lain on its side for some hours with an arm lying out on the floor, but that someone had turned it onto its back after rigor had become established. In most cases, the pathologist could confirm this change of posture by the inappropriate distribution of the lividity caused by “post-mortem hypostasis”. This discoloration of the skin results from the blood settling in the lowest-lying parts of the body, due to gravity, after the circulation has ceased.

Finally, I must mention one strange variant of rigor mortis, another phenomenon beloved of crime-writers. This is “cadaveric spasm”—firm rigidity of the muscles in one or more limbs, occurring almost immediately after death. It happens almost invariably in sudden, violent deaths, such as in battle casualties, victims of gunshot wounds, people who have fallen into water and the like.

The mechanism is obscure and most forensic pathologists will see only a couple of cases in their professional lifetime. The fascination for novelists lies in the fact that

the victim may grasp an object in a vice-like grip at the point of death—a victim of murder may seize a button or lock of hair from his or her assailant or someone who has committed suicide may grasp the gun or knife.

The fictional uses to which writers have put this phenomenon far exceed those of reality. In most instances, the person has fallen from a height or into water and literally “grasps at straws” on the way down. I have seen corpses that have ivy gripped in their fingers after a fall down a wall, or weeds and grass following drowning. Cadaveric spasm is said to be common on the battlefield, but this is outside the experience of most civil pathologists.

In practical terms, the timing of rigor mortis is far too variable to be of any use in estimating the interval since death, except in the crudest fashion. Yet without doubt, our library books and television screens will continue to exhibit wonders of medical deduction based on a perfunctory tug at the corpse's forearm.

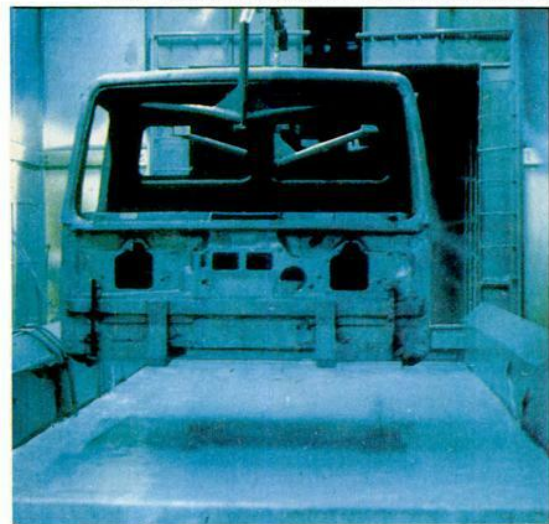
Bernard Knight

Bernard Knight is a barrister and a Home Office pathologist. He is professor of forensic pathology at the University of Wales.

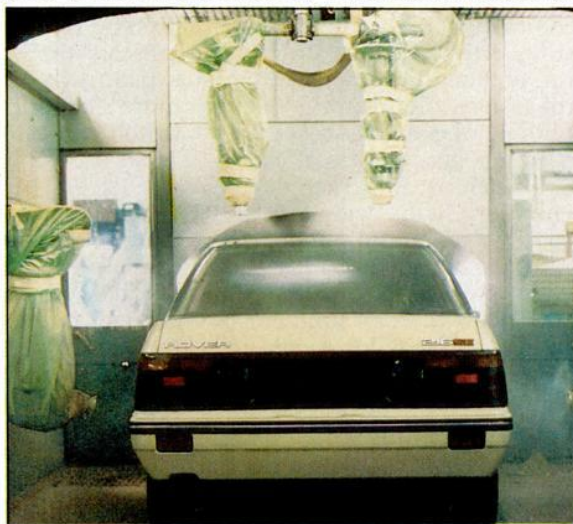


Michael Holford/BM

This wall painting from Nebamun's tomb in Thebes is dated about 1400 BC, some 600 years after the Egyptians first made paint



Painting with electricity: the body's electrical charge attracts paint when it submerges



Spraying a temporary, water-based paint onto coachwork protects it while the car is delivered



An alkaline solution cleans off the temporary paint

Paint is only skin deep

The main defence in the battle against rot is often only a thin layer of paint. The newest paints are powders that spread themselves with the aid of electric charges

John Nicholson

PAIN'T IS changing. Powder coatings and "solid" emulsion paints are taking over from liquid paints based on organic solvents. The brush is giving way to heat and static electricity in the application of paint. But paint has a more conservative image: paintmaking is seen more as a craft than a science. For much of the history of paint, it was indeed painters who developed the technology of making paint.

For this reason, we are more familiar with the works of artists who were also excellent paint technologists—the works of their contemporaries may have been just as good, but they have not survived the ravages of time. Leonardo da Vinci may not have been the greatest painter of his day; but his technical superiority over his rivals ensured that his works have survived while those of his contemporaries have not. Though Leonardo's fame rests on his many other achievements, part of his greatness was as a paint technologist.

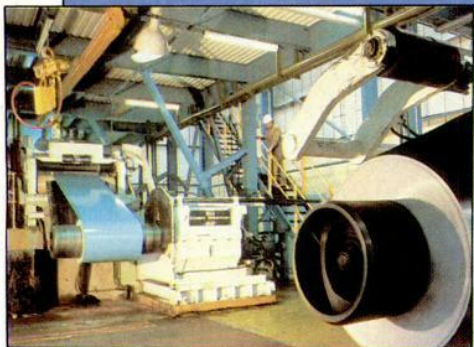
A driving force for change in the paint industry is rising costs, in particular of energy, raw materials and labour. Paint also has to contend with new materials encroaching on its territory—laminates and coloured plastics are taking over many roles from materials with painted surfaces. Concern about pollution and health also adds to the motivation for

developing paint technology.

Traditionally, paints have relied heavily on solvents to carry their main ingredients. Paint contributes substantially to the release of volatile organic compounds into the atmosphere—thought to amount to something like 360 000 tonnes each year. Some of these solvents, such as white spirit, are suspected of damaging the environment. Solvents also come mainly from crude oil which, despite recent fluctuations, will become more and more expensive. So the search is on for alternatives to organic solvents.

Conventional paint consists of three main ingredients: a binder (the film that holds everything together), a pigment and a solvent. The ancient Egyptians knew about the technology of producing and applying paints based on these three compounds 4000 years ago. They made a white water-based paint similar to distemper by mixing a casein binder with powdered chalk (pigment) and water.

The basic nature of the various components has changed gradually over the years, though their functions remain the same. Like their predecessors, modern paints consist of binder, pigment and solvent. Now, the binder is a synthetic polymer and the pigment is a material such as titanium



Painting coils of sheet steel before the steel is shaped into products



The sheet is uncoiled, coated in paint, dried in an oven and then recoiled



A workman forms a gutter on-site, from white, coil-coated steel



Coil-coated steel is used for roofs and walls in buildings like these as well as domestic goods such as refrigerators. The steel's skin of paint must not crack when the metal is pressed into shape and it must be consistent in colour from one coil to the next

dioxide or copper phthalocyanin. Most modern paints also contain fillers, which are effectively part of the pigment system.

Fillers consist of powdered inorganic compounds, such as china clay (kaolin) or barium sulphate, and they improve the mechanical strength of the dried paint film. Pigments also strengthen the film; but fillers do not colour the final film. Although fillers on their own appear white, their refractive indices are similar to those of typical binders and so they look clear unless genuine pigments are also present.

The most commonly used pigment these days is a form of titanium dioxide. It is a pure, brilliant white colour, and has become widespread since the end of the Second World War. Titanium is now the metal we encounter most frequently in our homes and workplaces. In addition to the basic components, paint contains a host of other ingredients. These ingredients fulfil a variety of functions, such as improving viscosity, controlling how the wet film flows and ensuring that the paint dries at a satisfactory speed.

Paint either decorates or protects. The decorative function is the obvious one—many people prefer bright colours in the buildings in which they live and work, and decorate them accordingly. The idea of protection is not immediately obvious but economically, it is more important (Box 1).

The environment degrades both wood and metal and they must be painted for protection. A varied assortment of organisms attack wood. They include worms, beetles, fungi and moulds—most of these organisms are deterred by a thin coat of paint or varnish. Metals, in particular iron and steel, corrode in Britain's damp climate—painting is a cheap and effective way of preventing this. So, although you may have

bought your car because you liked its colour, that paint is actually doing an important technical job, slowing down and, it is hoped, stopping corrosion altogether.

The protection of a film of paint is remarkable in view of the fact that it is so thin. Typically, one of these films is about 25-50 micrometres thick. Some paints, such as heavy-duty paints for ships, may be as much as 250 micrometres thick, while protective lacquers inside food cans are generally as thin as 5 micrometres. For comparison, a page of *New Scientist* is about 75 micrometres thick.

Broadly speaking, paints can be divided into two groups, convertible and non-convertible. Convertible paints undergo some kind of chemical reaction as they dry. They end up as a three-dimensional network of polymer chains, which is said to be cross-linked. Cross-linking prevents solvent molecules from getting into the film, so that these paints generally resist attack. On the other hand, non-convertible coatings, which dry by solvent evaporation alone, are not particularly tough. They can dissolve again in the right solvent and they may also soften and become tacky in hot sunlight.

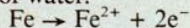
One trend in the manufacture of paint is to reduce the use of organic solvents. The idea of replacing organic solvent by water is especially attractive. Water makes paints which can be applied in the same way as conventional paints containing organic solvents. Paints with a water solvent smell less, are harder to ignite and, above all, cost less. Water is generally cheap and widely available, in the developed world at least. With water-based paint it is easier to clean brushes and other application equipment, and this is much appreciated by the do-it-yourself decorator, and by industry.

Water-based paints, however, have problems. The main

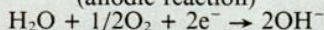
1: The cost of corrosion

THE Hoar* report estimated in 1971 that corrosion costs Britain £1364 million a year. Today, inflation puts this figure at about £6500 million.

Corrosion is an electrochemical process that occurs on the surface of ferrous metals between areas that release electrons and areas that consume them, generally by the electrolysis of water:



(anodic reaction)



(cathodic reaction)

Paints protect metal surfaces from corrosion either by providing a barrier to one of the reactants (ions, oxygen or water), or by inhibiting the passage of any charge. There is a high electrical resistance at the interface of the paint film with the metal.

Fotobank/England Scene



It can cost £200 000 a year to maintain a pier's paintwork

Conventional paints for ferrous surfaces are based on chlorinated rubber. This makes a non-convertible coating, but it is a very good barrier against water and corrosive salts. Chlorinated rubber has protected structural steelwork successfully for many years. More recently, though, ICI introduced an "emulsion" paint for steel, called "Haloflex". This is a copolymer, mainly of

vinylidene chloride with some vinyl chloride, which was modelled on chlorinated rubber. The new paint is water-based and does not release organic solvents into the atmosphere. It is beginning to replace chlorinated rubber in industrial paints. □

* Report of the Committee on Corrosion and Protection, Chairman Professor T. P. Hoar. Published by HMSO, 1971.

one is that they often stay sensitive to water after drying. There are other problems, in one instance, an industrial buyer found that water-based paint could not be used in a plant because all the pipes were of mild steel. The paint made them rust. One way to overcome the sensitivity to water is to use emulsion paints (Box 2). These paints resist attack by water—once they are painted on and dried—because the paint's binder is dispersed rather than dissolved. Another way is to treat the final film with heat. This causes chemical reactions in the coating to cross-link the paint binder.

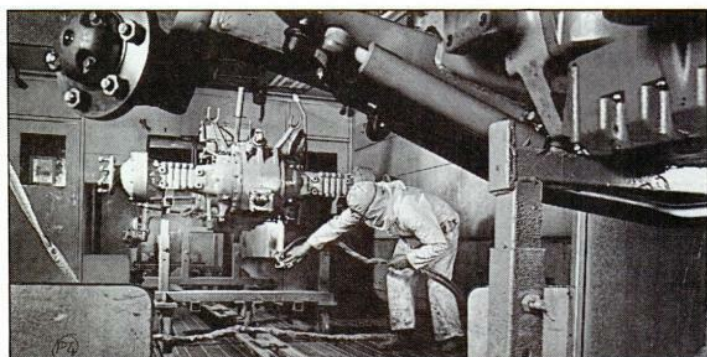
Sensitivity to water is no problem if you want to remove the paint. ICI recently developed a paint called Temprow, designed to be easily removed. It was originally conceived as temporary paint to ensure that cars arrived in the showroom without scratches or other marks. The paint is washed off by mildly alkaline solutions in a modified car wash. Since the launch, though, the paint has found other uses including changing the camouflage of military vehicles temporarily from green and black to white during winter exercises.

Another part of the car industry has found that temporary paint will show up the small dents in bodies and panels which cannot be seen until the metal has been painted, but which then have to be tapped out, ruining the paintwork. Now, temporary paint—a black gloss—makes these imperfections stand out. These panels and bodies have to go through an alkaline treatment anyway and this washes off the paint. Lastly, white paint based on Temprow marked out the route of the recent London marathon. It was easy to clean up the marks after the race.

Another useful quality of water-based paints is that they can be applied by electrodeposition. This technique, which needs an electric current, has been employed industrially for more than 20 years, mainly to prime car bodies. The object to be painted is immersed in a large bath of paint as one electrode of a cell. Water-based paint binders carry an electrical charge. When a current passes through the paint, the binder moves towards the object, where it deposits itself. The pigment also travels in the same direction, because its particles tend to have molecules of binder attached to them.

For many years, polymers containing negatively charged carboxylate salts were the binders in paints used in electrodeposition. These salts head for the anode, while the neutralising ion, usually ammonium, goes in the opposite direction. The free acids are less soluble than the salts, so the salts are deposited on the anode. More recently the technology has changed and so-called cathodic electrodeposition is becoming more common. In this technique, the molecules of the paint binder are positively charged, so they travel to the cathode rather than the anode in the painting bath. The resulting primers resist corrosion better than the anodic types.

An alternative method to reduce the use of solvents is to



Spraying epoxy paint on tractor chassis

increase the relative amount of pigment and binder (the so-called solids) in the paint. This is not as simple as it sounds: increasing the concentration of solids in a conventional industrial paint results in a stiff paste that is too viscous to be applied. The viscosity of a polymer solution depends on the size of its molecules, so the way to make "high solids" paints thin enough to apply is to make the binder from smaller molecules. The choice of smaller molecules is important because they must react well enough with each other to form the cross-linked network of the final film. Paint technologists have tried various molecules for these paints. Isocyanates are particularly useful, because they are stable in the can, and moisture in the air activates them. An isocyanate film builds up the cross-linked network very effectively.

The last way to reduce the emission of solvent is to do away with the solvent altogether, in other words to have all the paint solids mixed together as a powder. This approach has been very successful commercially. These coatings, can be thought of as consisting of 100 per cent solids. They are sprayed onto metal surfaces, where they stick by electrostatic attraction. Heating the powder makes it flow and coalesce into a continuous film. At the same time, the heat activates certain chemicals in the powder. These chemicals react to form the necessary three-dimensional network. After this first heating, these coatings become insensitive to the effects of further heat and resist attack by chemicals. Epoxies and polyesters are both found as binders in powder coatings. These coatings are put on products such as aluminium window frames and heavy-duty machinery.

As well as changes to the ingredients of paint, there has been a big change in how paint is used. These days, for example, more and more articles are made from pre-painted steel strip. This is known to the paint industry as "coil coating", because the strip is transported as a giant, painted coil. A highly automated factory coats paint onto the metal by unrolling a massive coil of steel, and passing it through a paint

MF Industrial

2: What's in a can of paint?

EMULSION paints are not, in fact, made from true emulsions. Strictly, emulsion means a dispersion of one liquid in another, for example fat droplets in water, which is the basis of milk. The so-called emulsion paints are actually made from solid polymers dispersed in water. This is correctly known as a latex.

Polymers are large molecules formed from smaller molecules, or monomers, joined together. The monomers in an emulsion paint determine its properties. Methyl methacrylate, for example, helps the paint to resist weathering, while acrylic acid disperses the binder in the water and makes the dried paint harder. Other monomers are water-loving, or hydrophilic, and they keep the latex stable. Synthetic detergents also help to maintain this stability.

A dispersion of polymers in water has a very low viscosity, even when the paint's pigment and filler are mixed in. Emulsion paints need a thickener to give them the right texture for brushing. Thickeners, which also stop the pigment settling in the tin, are usually a modified compound of cellulose.

When emulsion paints dry, the individual polymer particles must coalesce and embody the pigment if they are to form films. Polymers for paint must, therefore, be soft and easily deformed. These properties depend on temperature. Most commercial emulsion paints form powdery coatings

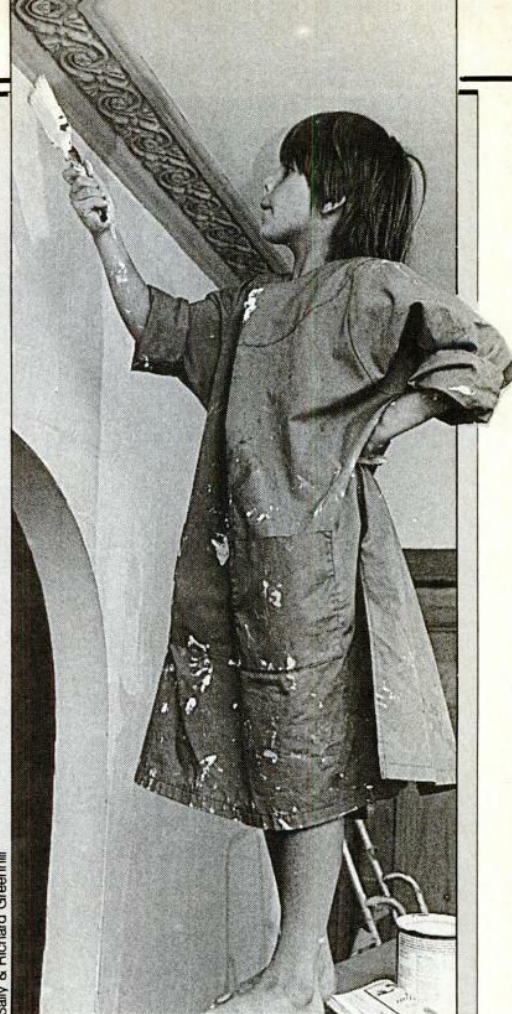
instead of films if they harden below temperatures in the range 3-12° C.

Two sorts of reactions join monomers together to form polymers. Addition polymerisation is a reaction between like monomers that contain double bonds between their carbon atoms. The bonds break and allow polymers, with carbon atoms joined by single bonds, to form. In condensation polymerisation, on the other hand, different compounds react together to form polymers known as alkyd resins. It also produces smaller molecules, such as water, as a by-product.

Polymers are usually divided into thermoplastics, which consist only of long chains of molecules, and thermosets, which have chemical bonds between the chains. These bonds, known as cross-links, usually occur in condensation rather than addition polymerisation.

Molecular differences between thermoplastics and thermosets give them different properties. Thermoplastics, for example, melt and solidify easily and organic solvents attack them. Thermosets, on the other hand, do not melt and most solvents do not affect them. Objects made of thermosets, such as an electric plug, can be thought of as a giant molecule because of the cross-links between their chains of polymers.

Water-based paints will wash off before they dry and harden



Sally & Richard Greenhill

sprayer—it then goes through a hot-air oven to dry and cross-link the paint. The steel is recoiled, and taken to the factory for components to be stamped out and assembled.

Most fridges, freezers and washing machines are made from coiled steel. Pressing the steel sheet makes severe demands on the paint. Not only must it withstand coiling, uncoiling and stamping, but the colour has to be excellent and reproducible. In the old days, when appliances were painted after assembly, it did not matter if there was some difference in shade between one article and the next. Now, when sides stamped out from one part of the coil are assembled with fronts from another part, there is very little scope for variation. Even slight differences are obvious to the customer, who will not want to buy a machine with sides that do not seem to belong to its front. Here, as in other areas, the paint industry has risen to the challenge and manufacturers paint to within very narrow colour tolerances.

With all these technical innovations, it would be tempting to think that technology leads all developments in the paint industry. But this is not true. The industry has also made a number of innovations in marketing. For example, the introduction of extremely pale colours for the DIY painter has been a great success in recent years. They owe nothing to new technology and everything to marketing. It was the skill of companies in advertising and selling which both created and satisfied the demand for these products.

Nevertheless, paint is a substance of increasing technical sophistication. In view of paint's low cost, its effectiveness in brightening our lives and protecting materials is truly astonishing. And with every prospect of its performance improving in the future, paint is going to be worthy of our respect for a long time to come.

Dr John Nicholson is a senior scientific officer at the Laboratory of the Government Chemist. He works in the materials group on projects related to paint and surface coatings.

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From a strike to a kill

Pilots and ground crew reported more than 500 incidents of birds colliding with planes in Britain last year. Airports take steps to control the problem, but standards vary enormously

Malcolm Smith



Austin Brown

EVER SINCE 1961, when a flock of starlings hit an Electra aircraft taking off at Logan Airport in Boston, no one has underestimated the seriousness of birds colliding with planes. The Electra crashed, killing all 62 people on board.

So far, Britain has escaped major disasters from collisions between aircraft and birds. The most serious incident to date occurred on 20 November 1975, when an HS125, a small twin-engined passenger jet, sucked lapwings into both engines during take off in Surrey. Only one of the eight people on board was injured, but six people were killed when the aircraft crash-landed, slewed across a road at the end of the runway and crashed into a car. A Fan Jet Falcon, an executive jet, drew gulls into both of its engines as it took off from Norwich on 12 December 1973. Three of the crew were injured when the jet crash-landed. The plane was seriously damaged, but the six passengers escaped unhurt.

The Directorate of Aerodrome Standards of the Civil Aviation Authority (CAA) gives detailed guidance on measures to control birds for the operators of all civilian airports and aerodromes in Britain. Indeed, the CAA's licensing provisions state that, where a problem exists, "all reasonable steps must be taken to minimise the risk". However, although larger airports, particularly busy international ones such as Heathrow, Manchester and Gatwick, have active programmes for controlling birds, many small, provincial aerodromes take few steps to clear birds from the area.

The CAA's Safety Data and Analysis Unit at Redhill, near Gatwick in Surrey, coordinates and analyses reports of collisions between aircraft and birds throughout Britain.

Airports must report any incidents resulting in damage or danger, under Article 82 of the Air Navigation Order, 1980. Pilots and other flight crew report most of the incidents, but ground and maintenance staff report a good proportion. On average, there are about five such incidents per 10 000 landings and take offs. In Britain, more than 90 per cent of collisions between birds and civilian aircraft occur at altitudes of less than 240 metres at or near aerodromes. The proportion is similar in other countries.

In 1985, the CAA received details of 556 collisions between aircraft and birds around British airports, and another 140 involving British flights at foreign airports. Each report gave details of the species and number of birds involved, weather conditions, the type of aircraft, its altitude and location, the manoeuvre being undertaken, the time of day and the damage caused.

A Boeing 737, owned by Britannia Airlines, taking off at Luton Airport on 9 June, sucked a pigeon into one of its engines and suffered severe engine damage. The pilot aborted the take off. A Dan-Air 737, climbing out of Newcastle Airport on 3 March 1985 in rain, collided with a flock of lapwings. The plane was forced to land and had to have an engine replaced. A British Airways Concorde, climbing out of the J. F. Kennedy International Airport in New York on 21 November, took a gull into one of its engines. The pilot jettisoned the fuel and landed safely, but again the engine had to be replaced. A British Caledonian DC10 hit a flock of black-headed gulls on 7 January 1985 while taking off from Gatwick: the birds hit the landing gear, flaps and one engine, damaging three fan blades. After a precautionary landing and

flight.

check, the plane was able to resume flight. Although most collisions do not seriously damage the aircraft, a plane's tyres may burst if it is forced to land. Pilots are attracted by birds during take off or landing, which can be dangerous, and is an unknown quantity.

Compiled by John Thorpe of the CAA, gulls are the main offenders in Britain. They are responsible for 30 per cent of all reported incidents, mainly black-headed gulls, which breed around inland areas. Collisions involving common, black-headed gulls. Airports near the sea are most problematic with gulls, and the CAA has a list of 100 species of birds which are a particular nuisance if they are in large communal roosts cross the area. A million gulls roost on reservoirs here.

Species of birds, from partridge, snipe, pheasant, to swallow, skylark, blackbird, has been involved in collisions with aircraft. Gulls are the second most common offenders, accounting for 26 per cent of reported collisions. Other common problems: feral and homing pigeons account for over 4 per cent of incidents. The CAA has an agreement with the Royal Pigeon Racing Association that racing pigeons cannot be released *en masse* within 8 miles of large airports. Fourteen days' warning must be given if pigeons are to be released near smaller airports.

Last year, the J. F. Kennedy International Airport published the most comprehensive study so far of the factors affecting bird strikes at airports. Joanna Burger of Rutgers University spent eight years at the airport studying the problem. Between 1973 and 1981, 49 species of birds collided with planes at the airport: nearly half of these incidents were attributed to gulls, and the rest to a motley collection of ducks and waders (the airport is by the sea), starlings, owls, pigeons, egrets, cowbirds, sparrows, buntings and other small birds. Pilots recorded 142 incidents, but 1202 carcasses of birds were picked up from runways. The low rate of reporting is probably because birds are hit in flocks, and because pilots, naturally preoccupied during take off and landing, fail to notice an impact unless the bird is a large one or they can hear

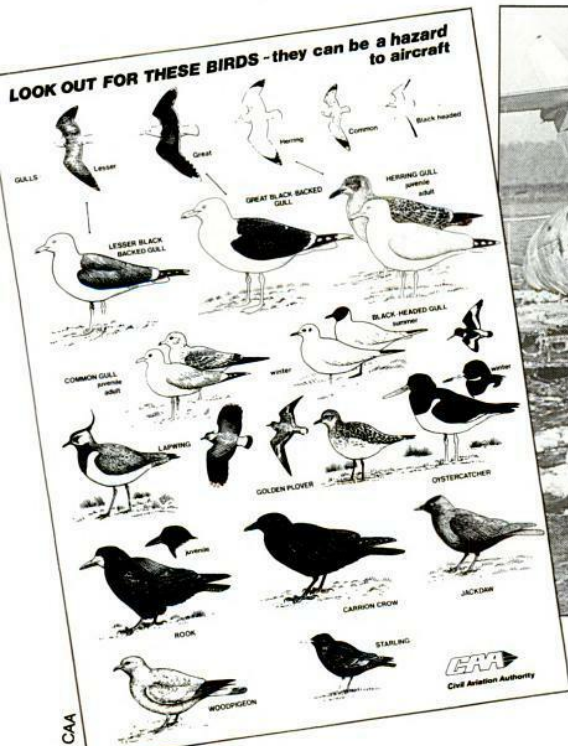
the thump. The faster and quieter wide-bodied planes, such as the 747 and the DC10, are struck seven times more often than the older, narrow-bodied jets such as the Boeing 727.

Birds may be simply unable to hear a jumbo coming. Busy airports are noisy places, and the noise of a wide-bodied jet at take off may be indistinguishable from the background din. Like the planes themselves, which take off and land into the wind, birds usually perch facing the wind, so their backs are turned towards the approaching aircraft. As the plane approaches, a bird flying off at around 35 kilometres per hour into the wind is bound to be struck or overtaken by a plane moving at over four times that speed. Jumbo jets, with their larger fronts, are more likely to hit the bird. Today, wide-bodied jets account for about half of the civilian aircraft using major international airports; in 1974, they accounted for only one fifth. When a jumbo jet looms, the standard evasive tactic employed by most gulls doesn't help. They zigzag erratically in front of it. Young gulls are struck more often than adults, suggesting that they know even less than adults about how to evade a plane.

Measures for controlling birds

Kennedy airport has fewer collisions between birds and planes than most international airports, even though part of the airport butts on to the Jamaica Bay Wildlife Refuge—a coastal bay with marshes and mudflats full of ducks, gulls and waders. There are two rubbish dumps within 400 metres of the runways. The airport has an active programme to control birds. It sends two vehicles out on the runways from 0600 hours until 2000 hours each day, equipped with tapes that play birds' distress calls, a variety of pyrotechnic devices to scare the birds and a shotgun for what Burger euphemistically calls "stimulus reinforcement". The airport's authorities manage vegetation at the airport to reduce its attractiveness to birds. They remove trees, which could provide roosts for starlings, drain ponds and wet areas, destroy bayberry shrubs—good food supplies—and remove all refuse within the airport's perimeter. Closing the nearby municipal dumps would almost certainly improve matters further, as well as removing an eyesore that is often the first sight that greets the visitor to the US. Burger also suggests that more patrols should go out before 0900 hours, because most gulls come to grief in the early morning, many of them being hit while loafing on runways.

Nevertheless, Kennedy airport has had its share of serious incidents involving birds. On 12 November 1975, a DC10 of



No one, not least the Civil Aviation Authority, underestimates the threat from birds. Six people died when this executive jet was brought down by lapwings



Scare tactics: Callum Thomas, at Manchester International Airport, fires off a cracker shell to clear the area. Right: he keeps track of the enemy's movements

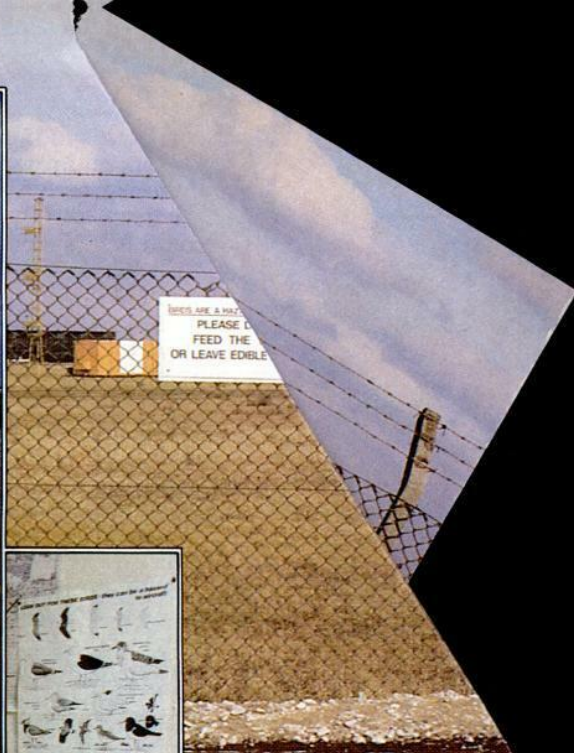
Overseas National Airways took a large number of gulls into one of its engines on take off. The engine disintegrated, setting fire to one wing: the plane did an emergency stop but ran off the end of the runway. The 139 passengers managed to escape but the plane, gutted by fire, was a write-off—at a cost of \$40 million. Between 1973 and 1981, incidents involving birds at Kennedy meant that six aircraft engines had to be replaced. Three more engines needed new fan blades, and dents had to be repaired in six other planes.

In Britain, the CAA gives staff of airlines and airports detailed information on how to identify birds, how birds behave at airports, the types of problems that may arise, how to manage vegetation and the most effective measures for controlling birds.

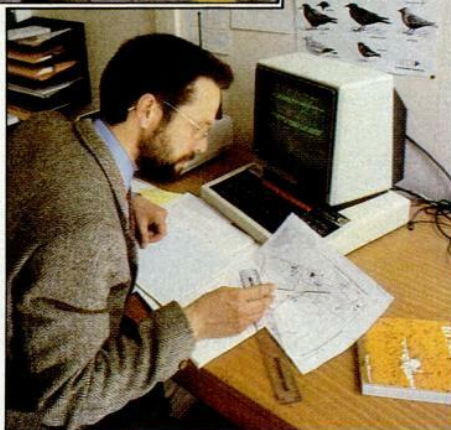
Gatwick's methods are typical of those employed by major airports in Britain. Twenty-three full-time staff spend much of their time scaring off birds and managing vegetation to discourage them. Around-the-clock patrols identify the species in and near the runways and play tapes of the relevant distress calls. As the birds move towards the dummy calls to investigate, the patrols fire a two-stage cracker shell into the air from a shotgun. It bangs once at the muzzle and once in the air, scaring the birds off immediately, though most species return within several minutes. Gatwick's problem is mainly with lapwings, herring gulls, black-headed gulls and starlings.

Distress calls alone can disperse the birds: they have the advantage that birds become accustomed to them more slowly than to most methods, but it often takes several minutes for the birds to leave. At night, patrols shine bright lights and blast sirens to clear runways and taxiways of roosting birds. Rooks—wiser birds by far (*New Scientist*, 10 October 1985, p 47)—have learnt to associate impending danger with the patrols' yellow vans, and disperse when they see them coming.

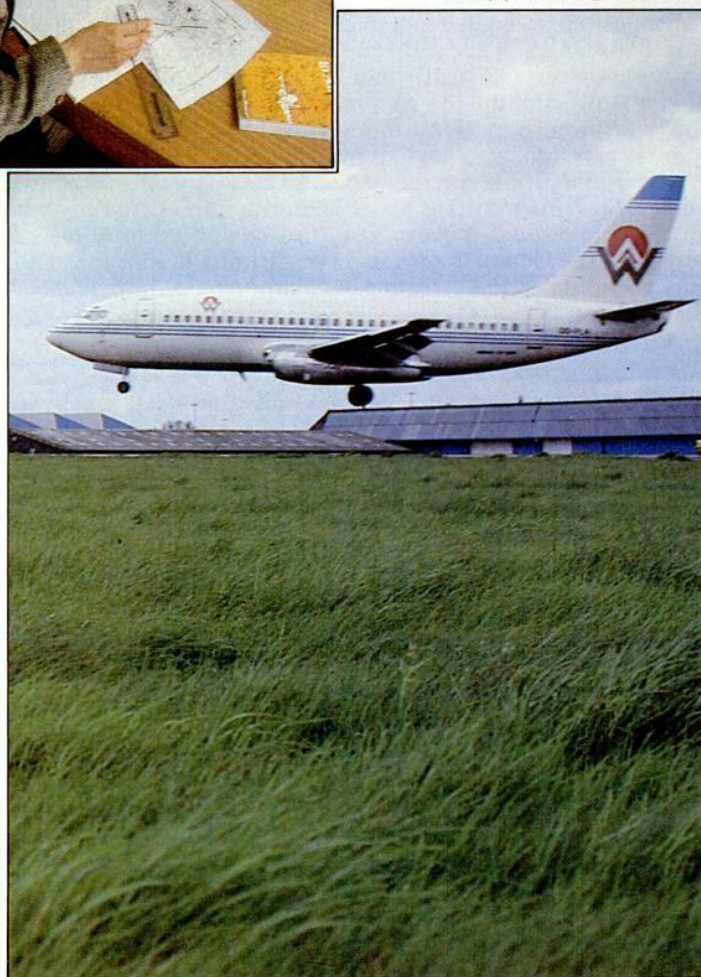
Environmental measures at Gatwick include a ban on rubbish dumps and sewage works near the airport's perimeter. Household refuse attracts birds, especially gulls and starlings. When not feeding, gulls spend hours sitting around digesting their rich pickings. Runways are excellent spots for loafing: they also provide an ideal surface for gulls to break up bones by dropping them. Bones, shells and tin cans



Passengers, too, can play the part. Feeding the birds could endanger their flight



Cutting it long: long grass is one of the best ways of keeping birds away from airports



carried by scavenging gulls and dumped on runways are themselves a hazard to the tyres and engines of aircraft.

Keeping the grass long—airports used to be mown regularly—is the single most successful measure in reducing the number of birds. This strategy was tested at Gatwick before the CAA recommended it at all civil airports in Britain. All grass between runways at Gatwick is kept long—the CAA's recommended length is about 20 centimeters—because birds are reluctant to land and feed in long grass. Long grass also denies birds the opportunity to spot predators, making them even less keen to land. The Royal Air Force has found that long grass, as opposed to short turf, reduces the number of birds by two-thirds.

At Manchester International Airport, Callum Thomas, the only full-time Bird Control Officer to be employed at a British civil airport, is responsible for controlling birds over 500 hectares at the airport, including 150 hectares of grassland. Many of the measures taken at Manchester were in operation before Thomas, a professional ornithologist, took up his post six months ago. They include scaring birds and managing the grass, as well as applying lumbricides to the grass at the edges of the runways to prevent earthworms moving on to the runways during wet weather. Worms attract birds to runways.

One extra but simple measure that Thomas has introduced is to have "Don't feed the birds" signs erected at the airport's hotel and pub, and along roads running next to the perimeter fence. He is also preparing a document that gives guidelines to the people who plan airports. The aim is to encourage planners to think about requirements for controlling birds at an early stage. For instance, any topsoil should be seeded to produce a grass monoculture, with no other species which attract birds. Clover has to be excluded because wood pigeons are attracted to it. If any trees are planted, they have to be kept far apart to prevent starlings roosting.

Last year, Gatwick reported only 15 collisions between aircraft and birds, and Manchester International Airport 40, despite the fact that Gatwick handled nearly twice as many flights (89 000 landings and take offs). Heathrow, which handled 138 000 landings and take offs, reported 65. But smaller airports, often with far fewer flights, also reported substantial numbers of collisions. Belfast Aldergrove (with 31), Birmingham (also 31), East Midlands (20) and Luton (25), all with between 20 000 and 30 000 landings and take offs a year (three or four times fewer than Gatwick), had particularly high incident rates. An even higher number—35 strikes—was reported at or near the Isle of Man's Ronaldsway Airport which has less air traffic again. The airports at Newcastle, Leeds, Liverpool and Stansted are about as busy as Ronaldsway but had fewer incidents (24, 18, 15 and 12 respectively). Aberdeen, five times busier than Ronaldsway, though mainly with helicopter flights, had only 11 reported incidents.

British airports have so far managed to avert a major disaster as a result of collisions between aircraft and birds. As we learn more about the behaviour of birds at airports, scaring techniques and better management of vegetation could prove to be increasingly effective deterrents. But at present efforts to control birds vary enormously. Although Britain's main international airports, with large numbers of flights, have relatively few collisions, many of our smaller airports have poorer records, especially when one considers that they handle a lower volume of traffic. Sooner or later, we are bound to suffer a disaster at a British airport. When we do, the odds are that it will be at a provincial, rather than an international, airport. □

Dr Malcolm Smith is a biologist and writer with an interest in environmental issues. He is based in North Wales.



"Animal experiments that are unnecessary, use unnecessarily large numbers of animals, or are unnecessarily painful are indefensible."

(Government Supplementary White Paper—May, 1985.)

"LABORATORY ANIMALS—THE DAWN OF A NEW ERA"

In 1979, the Committee for the Reform of Animal Experimentation (CRAE) set out four objectives required in new legislation:

1. The restriction of pain.
2. A substantial reduction in the number of animals used.
3. Development and use of humane alternatives.
4. Greater public accountability.

The Scottish Society for the Prevention of Vivisection (SSPV) through its involvement with CRAE, believes that the *Animals (Scientific Procedures) Act 1986* achieves these objectives.

If you would like information on the new legislation; the role played by the Society before and during its passage through Parliament; and on the Society's work in general, send for a free copy of its 1986 Annual Pictorial Review.

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New alloys from the quantum engineer

Designing new light-weight alloys for building aircraft and other applications has always been a hit-and-miss affair. Now quantum mechanics is starting to play a role in predicting the properties of complicated materials

David Pettifor

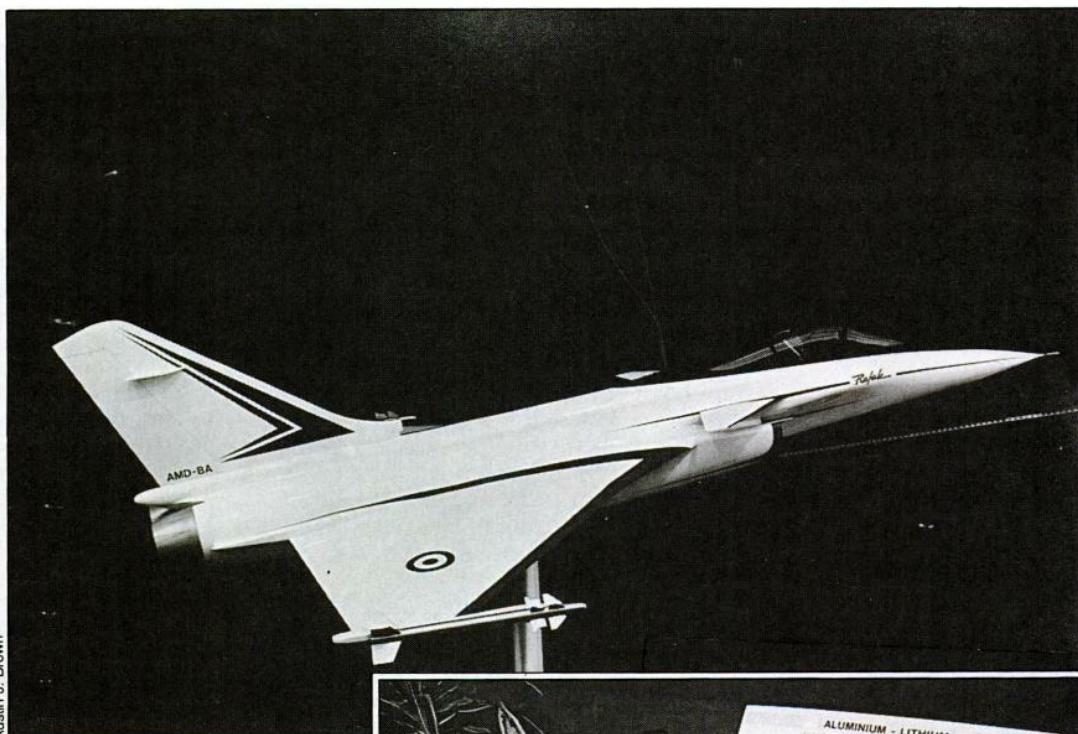
WHAT CAN the microscopic world of quantum theory offer the industrial world of alloy design and production? Until recently, the answer was nothing. But dramatic new advances in both theory and computation now open up the prospect of quantum mechanics playing a central role in the search for and design of new alloys.

Quantum mechanics has shaped the conceptual framework of those engineers who design new types of "chips" and other semiconductors, but metallurgists have seen little scope for the application of quantum mechanics to their everyday research. This is not a matter of idle prejudice or failure to understand the intricacies of quantum mechanics. It reflects the fact that when theorists tried to solve the fundamental equations of quantum mechanics, they had to make approximations that were so crude that the errors were simply too large for the results to be of any use in predicting the properties of new alloys. The past decade has seen a revolution in the predictive power of quantum mechanics.

Physicists and engineers are excited about these developments because, hitherto, the design of new alloys for industrial use has been a hit-and-miss affair. The development of modern aluminium alloys for the construction of aircraft is a prime example. The history of these alloys clearly illustrates the uncertain path linking the initial specifications, which the designers have to meet, and the finished product.

Aluminium is a good candidate for the construction of aeroplanes, because it meets two important specifications. Firstly, it is light, with a density only 2.7 times that of water and one-third that of iron or steel. Moreover, it is very easy to work: it is ductile, a property necessary for the shaping and manufacture of the aircraft components. Unfortunately, however, pure aluminium does not meet a third crucial specification, namely that the material should have a high yield strength. Relatively little effort is needed to pull a rod of pure aluminium apart. Aluminium fails too easily: the pure metal has too low a yield strength for structural use.

The German chemist Alfred Wilm discovered that he could strengthen aluminium by adding a few per cent by weight of copper. In September 1906, he was investigating the yield strength of many different alloys of aluminium in his laboratory near Berlin. Apparently, he measured the hardness of one aluminium-copper alloy very hastily one Friday, recording a value of 70 (in arbitrary units). Being conscientious, he repeated the measurement the following Monday morning, and found to his surprise a value of 100. Later experiments showed that aluminium-copper alloys



Austin J. Brown



Aviation Picture Library

On display at the Paris air show last year: how the Dassault Rafale fighter aircraft depends on aluminium-lithium alloys

indeed hardened with age.

Wilm's chance discovery marked the birth of alloy design. Metallurgists soon realised that these alloys had been strengthened because very small particles of aluminium-copper had precipitated out within the "matrix" of pure aluminium. If we look at these particles under an electron microscope, they are uniformly distributed throughout the alloy, looking rather like droplets of water in a fine mist. These particles block one plane of aluminium atoms from sliding over another and hence they dramatically increase the yield strength of the pure metal. By judicious tinkering with the relative amounts of copper, and also magnesium, added to the host aluminium, metallurgists made a highly successful use of these "duralumin" alloys within the aircraft industry, starting with the Zeppelins of the First World War.

The search for even lighter alloys, which would reduce fuel consumption and hence the cost of air travel, has since focused on alloys of aluminium and lithium. Lithium is by far the lightest metallic element, with a density that is only half that of water. Adding 2 per cent by weight of lithium to aluminium reduces its density by about 6 per cent. Unfortunately, such an aluminium-lithium alloy is unsuitable for building aircraft. Although the addition of lithium increases the yield strength of pure aluminium by an order of magnitude, it decreases its ductility by a similar amount. The alloy is too brittle and fractures too easily for structural use.

During the 1950s, the American metal manufacturer Alcoa thought that it had overcome this problem by developing a high-strength aluminium-lithium alloy, which contained about 5 per cent by weight of copper. However, it had to be withdrawn as a commercial alloy in 1969 because it was not sufficiently ductile.

Rapidly rising oil prices in 1973, however, saved alloys of aluminium and lithium from obscurity. Small reductions in the weight of an aircraft could produce big savings in fuel consumption and so enhance profitability. Metallurgists became even more determined to develop a successful light-weight alloy. Recently they have found that adding a few tenths of a per cent by weight of zirconium to an aluminium-lithium alloy (containing copper and magnesium) increases its ductility without impairing its yield strength.

Aircraft manufacturers predict that the next 10 years will see a shift from conventional alloys to alloys of aluminium which contain 2 to 3 per cent of lithium by weight. Using these alloys should allow reductions in the weight of aircraft of up to 15 per cent. Thus, after many decades of intermittent progress, the designers will at last have an aluminium-lithium alloy that meets the specifications of low density, high strength and high ductility.

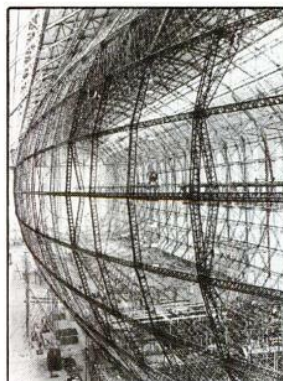
How can quantum mechanics help the designer achieve the desired properties for a new advanced alloy more directly and less fortuitously? We know that it is the presence of fine particles within the aluminium matrix that affects the mechanical properties of aluminium-lithium alloys. These particles consist of aluminium and one or more of the alloy's constituents, combined together in some particular ratio, for example, 1:1 in AlLi , or 3:1 in Al_3Li . Since they have a definite composition and are formed from two or more metallic constituents, these particles are intermetallic compounds. (There are special cases of intermetallic phases—see Box 1—where the chemical composition may vary slightly but the geometrical structure remains constant.) The intrinsic mechanical properties of these "intermetallic compound phases" directly influences those of the host metal. For example, aluminium-lithium alloys are strengthened by the presence of Al_3Li particles, because this intermetallic compound has a high yield strength. On the other hand, the alloys become less ductile in the presence of AlLi particles because they are intrinsically brittle. It is desirable therefore for alloy designers to be able to predict not only which intermetallic compound phases will be found within their chosen alloy system, but also the intrinsic mechanical properties of the phases.

Only quantum mechanics can predict what particular structure a material will adopt and what its properties will be. The way in which constituent atoms of any material bind together at the microscopic level determines its macroscopic properties. But the valence electrons—which form the bonds—do not obey the classical laws of Newtonian mechanics. Instead they follow quantum mechanics, in the form of Schrödinger's equation. Thus quantum theory is a prerequisite for understanding and predicting the structural and mechanical behaviour of solids.

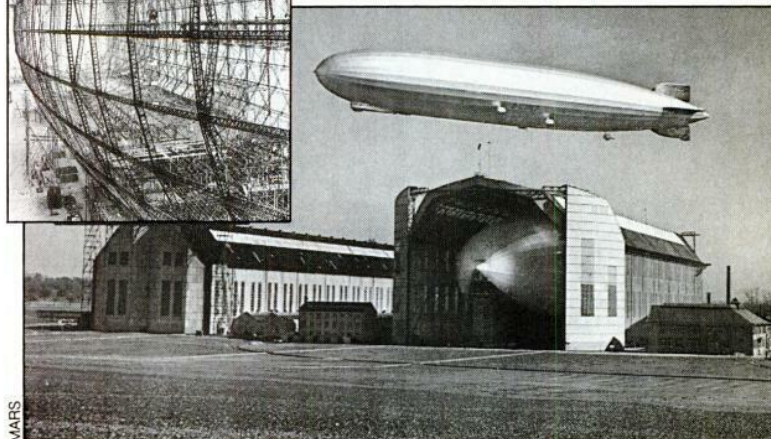
Eugene Wigner and Frederick Seitz were the first to apply quantum mechanics to the problem of bonding in metals. In what is now a classic paper, published in 1933, they solved Schrödinger's equation for sodium. Only the outermost elec-

tron of this metal takes part in chemical bonds—sodium is monovalent. Wigner and Seitz obtained theoretical values for the cohesive energy, atomic volume and compressibility of metallic sodium that lay within 10 per cent of the experimental values.

Solid-state physicists took nearly another 50 years to devise and implement a scheme of similar accuracy for polyvalent metals such as aluminium and iron. Wigner and Seitz assumed that the single valence electron on a sodium



Since the earliest Zeppelins, engineers have sought strong, light-weight alloys. Now quantum mechanics can help them in their quest



atom feels only the potential due to the ion's core. In a polyvalent metal, a given electron will also feel the strong repulsion due to the other similarly charged valence electrons in its vicinity. Pierre Hohenberg, Walter Kohn, and Liu Sham introduced a new scheme for handling the difficult problem of how polyvalent metals bond in the mid-1960s. In the 1970s high-speed computers and improved techniques for solving the equations made it possible for physicists to implement and apply the scheme to practical problems.

Progress in the design of alloys has been made by ordering and collating an enormous amount of empirical data. Ernest Rutherford once dismissively described this activity as stamp-collecting, not science. Designers of alloys have at their disposal nearly a hundred chemical elements that they can mix together in endless permutations. Even if they were to design the simplest possible system, a compound of equal proportions of two elements, they would still face some 5000 (or $100 \times 99 \div 2$) different systems displaying hundreds of types of structure.

To put the empirical data in some sort of order therefore presented a problem. To arrange and classify this structural data, metallurgists in the past used classical concepts. In 1926, the British metallurgist William Hume-Rothery proposed that the average number of valence electrons per atom determined whether the face-centred or body-centred cubic lattice (Figure 1) would be the more stable amongst alloys of certain noble metals. He knew that the intermetallic phase CuZn exhibited the same type of crystal structure as CsCl , shown in Figure 1d: he predicted that the Cu_3Al and Cu_3Sn would also adopt the body-centred lattice because the average number of valence electrons per atom in each case is $\bar{Z} = 3/2$ (assuming a valence of 1 for copper, 2 for zinc, 3 for aluminium, and 4 for tin). He made his prediction in the nick of time: after his paper had been submitted, but before it was published, experimentalists found that both alloys had body-centred lattices.

Metallurgists recognised that two other factors are important in determining the structure of materials. The first is the difference in the electronegativity, ΔX , of the constit-

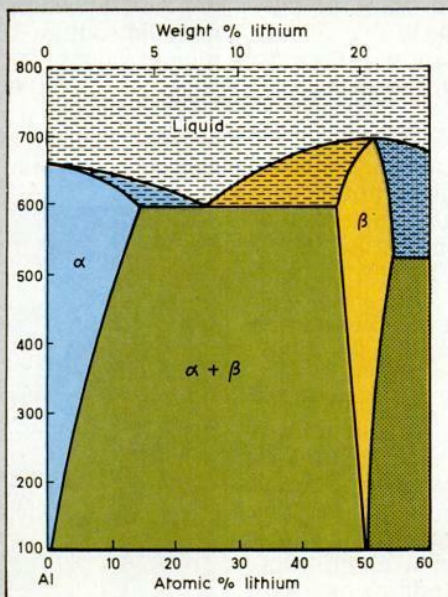
1: Phase diagrams and the quantum prediction of structure

HOW ATOMS bind and pack together at the microscopic level determines the mechanical properties of an alloy. To design any new alloy, we need to know how the constituent elements interact and bond with each other when they are isolated as simple, binary systems. This information on the structural properties of binary alloys is contained within the so-called phase diagram, from which the stable structures at any given temperature and composition may be read off.

The aluminium-lithium system provides a good example (right). The crystal structure of pure aluminium is that of a cube with the atoms at the centre of each face, as shown in Figure 1a. Lithium, on the other hand, adopts the body-centred cubic structure at room temperature—a structure whose basic building block has an atom at the centre of the cube, as shown in Figure 1b. An alloy consisting of equal proportions of aluminium and lithium also adopts the body-centred cubic lattice, as shown in Figure 1d. (For simplicity, the ordered CsCl structure-type is shown, rather than the related but more complicated NaCl structure that AlLi actually takes.)

The α and β phases shown in the aluminium-lithium phase diagram, correspond to face-centred and body-centred cubic lattices respectively. At room temperature, any alloy that contains less than 50 per cent lithium will consist of a mixture of the α and β phases co-existing in equilibrium: their relative proportions depending on composition.

Suppose we make an alloy of aluminium containing 1 per cent by weight of lithium by mixing the two molten metals and then cooling the mixture down from the molten



state very slowly. The phase diagram shows that above 250°C the alloy comprises the single phase, whereas below 250°C the alloy exists as a stable mixture of both the face-centred α and the body-centred β phases.

This separation into two phases occurs through the diffusion of lithium atoms. Above 250°C they are homogeneously distributed throughout the face-centred aluminium matrix. Below 250°C it is energetically favourable for them to arrange themselves heterogeneously. If we cool the alloy sufficiently slowly, the lithium atoms will have time to diffuse so that there will be

regions containing very few lithium atoms (which adopt the face-centred α phase) and other regions containing about equal proportions of aluminium and lithium atoms (which adopt the body-centred β phase).

However, this slowly cooled aluminium-lithium alloy, in which the α and β phases co-exist in equilibrium, is unsuitable for industrial use: the body-centred AlLi β phase is brittle.

Alloy designers suppress this unwanted equilibrium phase by plunging the molten mixture into cold water. This cools it so rapidly that the lithium atoms do not have time to diffuse and concentrate into regions in which every other atom is lithium. This quenched "solid solution" of lithium in aluminium, however, is not stable. In the course of time, the metastable phase Al_3Li precipitates out. This phase, which requires only one out of every four atoms to be lithium, takes the face-centred cubic lattice (see Figure 1c), and increases the strength of the alloy.

Larry Kaufman at Man Labs Inc in Cambridge, Massachusetts, and his worldwide network of collaborators have over the past two decades developed an extremely useful set of computer programs for calculating the equilibrium and metastable phases of alloys. These programs do not start from first principles, but rely on a sensible procedure for extracting information from the known binary systems in order to predict metastable structures and the phase diagrams of ternary systems, for which there is often very little experimental data.

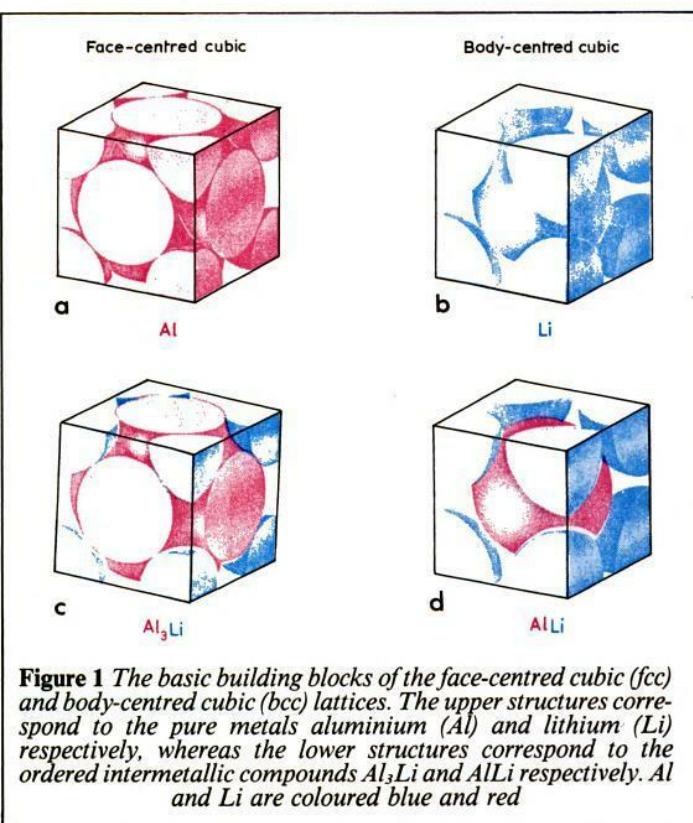
Some of the data on which this suite of programs bases its calculations are not

uent atoms. The electronegativity difference reflects the amount of electric charge which flows from one atom to another; the larger the electronegativity difference, the more ionic in character is the chemical bond between different atoms. Generally, metallurgists use the electronegativity scale first devised by the Nobel-prizewinning chemist Linus Pauling. The second important factor is the difference in size of the constituent atoms.

In 1983 Pierre Villars, then at the University of Waterloo in Canada, studied the data on the structures of 1000 compounds of equal proportions of two elements. He found that he could arrange the data by ordering it according to all three factors: the electronegativity difference ΔX , the size difference ΔY , and the average number of valence electrons per atom $\bar{Z}$. He constructed a three-dimensional grid, so that any given compound is characterised by some point (ΔX , ΔY , $\bar{Z}$). Villars considered 20 different types of structure and found that they usually separated into different regions within his three-dimensional plot. In other words, he managed to arrange the empirical data in such a way that he could characterise different structures by different values of the three parameters (ΔX , ΔY and $\bar{Z}$).

Ambitious though it was, Villars's map did not provide all the answers. First, three-dimensional plots are not easy to work with, and metallurgists had to draw 16 separate two-dimensional plots to display the data for these binary compounds. More seriously, the coordinates are classical not quantum in character; as one result of this, Villars's classification system could not deal with the fifth most important type of structure, that taken up by, for example, NiAs.

Classical concepts such as size and electronegativity



directly accessible to experimental confirmation, but can only be *inferred* from the behaviour of the phase diagrams themselves. For example, if we wish to compute the aluminium-lithium phase diagram, then the program needs to know, among other things, the energy difference between the stable face-centred structure of pure aluminium and the (hypothetical) body-centred structure. Because this structure is unstable (or at best metastable), it does not exist in reality under normal conditions and so experimenters have no direct way of measuring the relevant energy difference. However, the reliability of the computer predictions depends directly on the validity of these parameters. It is, therefore, important for the consistency of this data to be confirmed by "first principles" quantum mechanical calculations.

Physicists can solve Schrödinger's equation—the basic equation of quantum mechanics—exactly for only a few simple systems such as the hydrogen atom or a single electron moving freely in space. Most of the really interesting problems defy an exact solution because they involve the presence of more than one electron.

In 1928, Douglas Hartree in Cambridge found a way of working out the energy levels of atoms with many electrons. By regarding each electron as moving in the average electric field created by the negative charges of all the other electrons, and demanding that the whole procedure was self-consistent, he derived an approximate description of atoms other than hydrogen.

Unfortunately, the Hartree approximation fails to describe bonding in metals. It predicts, for example, that the metallic bond in aluminium is more than a hundred times weaker than that observed experimentally! The approximation

assumes that the individual electrons move independently of each other, influenced only by the *average* electric fields. This implies that there is no restriction on two electrons approaching each other very closely in the metal, even though we know that in practice, their mutual electrostatic repulsion will tend to keep them apart.

In 1930, Fock extended the theory to take account of Pauli's exclusion principle, which states that no two electrons can be in the same quantum state. (This principle is responsible for the periodic table since it leads to the progressive filling up of the electronic shells as the atomic number increases.) In metals, the Hartree-Fock approximation guarantees that no two electrons in the *same* spin quantum state can approach close together. This is, therefore, a much better approximation than Hartree's. However, there is still an error, because electrons in *different* quantum states could approach too close together. This error leads to the electronic specific heat, for example, varying with temperature as $T/\log T$. In practice, the specific heat of metals has a simple linear dependence on T .

In the early 1960s, Pierre Hohenberg, Walter Kohn and Liu Sham came up with a better description. In research carried out at the Ecole Normale Supérieure in Paris and the University of San Diego, they proved that the total energy of a system was a function of the electron density. This seemingly simple result leads to an effective Schrödinger equation, that has the same form as Hartree's original approximation—except that a given electron now feels an additional (negative) potential. This negative potential lowers the energy of the system, because a given pair of electrons no longer has the freedom (as in the

Hartree approximation) of approaching close together and experiencing their mutually repulsive electrostatic potential.

In practice, even here we need to take a short-cut if we are to compute the structure of real systems. We do not know the exact form of the additional potential, so we replace it by the one that would apply to an electron in a uniform gas of electrons—something that we can compute. Theorists thought that this approximation would work only for systems where the electron density was nearly uniform. But the fast computers that became available in the 1970s gave surprisingly accurate results for more complex systems such as atoms, molecules and solids.

Various groups around the world are using this "first principles" scheme for calculating the binding energies and structural properties of solids. For example, Art Williams and his colleagues at IBM's Yorktown Heights Research Centre have predicted the heats of formation of the body-centred and face-centred compounds of two transition metals. These and other calculations have aroused considerable controversy, because the quantum mechanical predictions for the energy difference between stable and metastable structures at low temperatures sometimes differ by as much as a factor of three from the values that Kaufman has inferred from the behaviour of binary alloys.

Recently, however, Peter Moidownik, a metallurgist from the University of Surrey and a close collaborator of Kaufman's, has reassessed the empirical data, taking into account new experimental values for the entropies of fusion. This reassessment leads to structural energy differences in much closer agreement with the quantum predictions. □

2: Stringing up the periodic table

THE QUANTUM character of the chemical elements is reflected directly in the periodic table. This two-dimensional arrangement of the elements is a consequence of Schrödinger's equation. Each element in the periodic table is characterised by two co-ordinates, namely its period and group. To classify the structures of binary compounds, I have reduced this to a single co-ordinate, as described in the main text by arranging the elements along a one-dimensional axis, their relative ordering being given by what I have called the Mendeleev number.

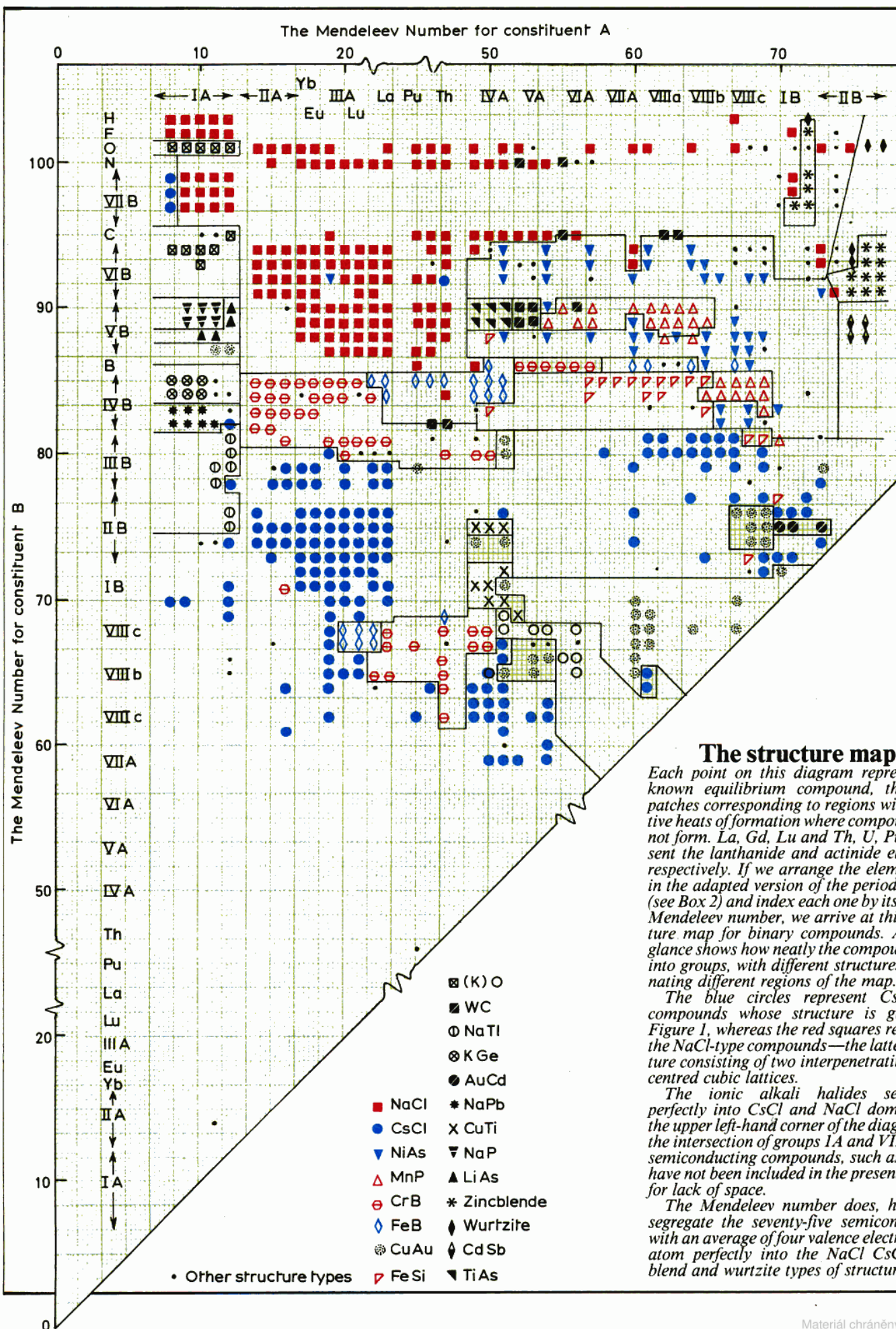
The arrangement of the periodic table shown here is slightly different from usual (*New Scientist*, 7 March 1985, p 32). This arrangement places the group IIA elements beryllium and magnesium with group IIB and separates the divalent rare earths or lanthanides (those that have two valence electrons) from the trivalent. The way I have ordered the elements in group IVA reflects the so-called lanthanide contraction; hafnium has a smaller core size than zirconium. My arrangement of group VIIC leads to a marginally better separation of structures of compounds than running the string straight from nickel to palladium to platinum. The anomalous ordering of gallium with respect to alu-

minium arises because gallium has a full core of *d* electrons. Chemists well know that the second row elements boron, carbon, nitrogen, oxygen and fluorine

behave differently from the other elements in their respective groups. They are much more electronegative due to the absence of p electrons in the core. $\square$

O		IA																		II B	III B	IV B	VB	VI B	VII B	103 H
1	12																	77	86	95	100	101	102			
He	Li																	Be	B	C	N	O	P			
2	11																	73	80	85	90	94	99			
Ne	Na	II A	III A	IV A	V A	V I A	VII A	VIII a	VIII b	VIII c	IB	Mg	Al	Si	P	S	Cl									
3	10	16	19	51	54	57	60	61	64	67	72	76	81	84	89	93	98									
Ar	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br									
4	9	15	20	49	53	56	59	62	65	69	71	75	79	83	88	92	97									
Kr	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I									
5	8	14		50	52	55	58	63	66	68	70	74	78	82	87	91	96									
Xe	Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At									
6	7	13																								
Rn	Fr	Ra																								
17	18	33	32	31	30	29	28	27	26	25	24	23	22	21												
Yb	Eu	La	Ce	Pr	Nd	Pm	Sm	(Eu)	Gd	Tb	Dy	Ho	Er	Tm	(Yb)	Lu										
		48	47	46	45	44	43	42	41	40	39	38	37	36	35	34										
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr										

The string running through this modified periodic table puts all the elements in sequential order, given by the Mendeleev number



The structure map

Each point on this diagram represents a known equilibrium compound, the bare patches corresponding to regions with positive heats of formation where compounds do not form. La, Gd, Lu and Th, U, Pu represent the lanthanide and actinide elements respectively. If we arrange the elements as in the adapted version of the periodic table (see Box 2) and index each one by its unique Mendeleeve number, we arrive at this structure map for binary compounds. A quick glance shows how neatly the compounds fall into groups, with different structures dominating different regions of the map.

The blue circles represent CsCl-type compounds whose structure is given in Figure 1, whereas the red squares represent the NaCl-type compounds—the latter structure consisting of two interpenetrating face-centred cubic lattices.

The ionic alkali halides segregate perfectly into CsCl and NaCl domains in the upper left-hand corner of the diagram, at the intersection of groups IA and VIIB. The semiconducting compounds, such as GaAs, have not been included in the present figure, for lack of space.

The Mendeleeve number does, however, segregate the seventy-five semiconductors with an average of four valence electrons per atom perfectly into the NaCl, CsCl, zinc blend and wurtzite types of structure.

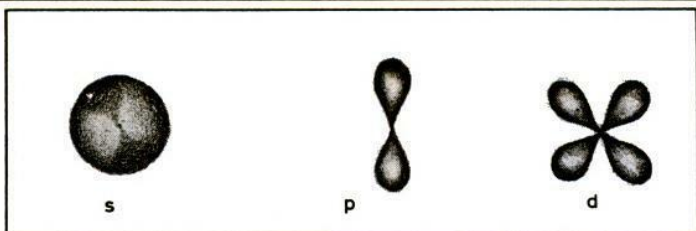


Figure 2 The *s*, *p* and *d* orbitals have very different shapes

cannot fully describe the behaviour of atoms and their valence electrons. (The valence electrons are the ones that are used to form chemical bonds.) A good example of the inadequacy of classical concepts is the bonding behaviour of the valence electrons in scandium and aluminium. Although both atoms have three valence electrons, these show very different quantum behaviour.

Aluminium lies in group IIIB of the periodic table and its valence electrons occupy *s* and *p* orbitals. Scandium is a transition element in group IIIA and its metallic crystalline structure is determined by the bonding between those of its valence electrons that occupy *d* orbitals. The *s*, *p* and *d* orbitals have very different "shapes" as Figure 2 illustrates.

The arrangement of the elements into different groups of the periodic table reflects the different ways in which the electronic orbitals are filled up and, hence, the quantum character of the valence electrons. This quantum nature of the orbitals, which is clearly important in determining the way in which atoms bind together to form a crystal lattice, is absent from the classical descriptions.

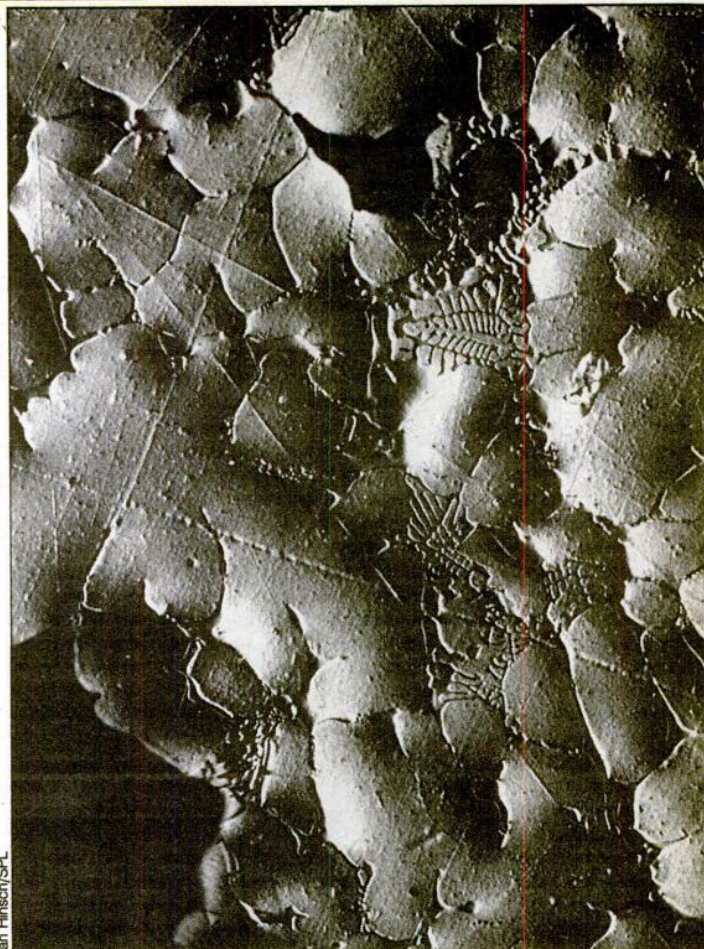
Also in 1983, I proposed a two-dimensional way of arranging the structures of compounds of two elements that, because it followed the ordering of elements in the periodic table, is based directly on the quantum character of the atoms that make up the compounds. To achieve this, I assigned a single number (which I have called the Mendelev number) to each element in the periodic table. Once I had established a unique number for each element, I could plot the structure data for compounds of two elements simply by plotting the two Mendelev numbers against each other.

A bright future

To reduce the two-dimensional structure of the periodic table to a single coordinate, we can, in imagination, run a string from one end of the table to the other, as described in Box 2. Pulling the ends of the string apart orders the elements along a one-dimensional axis; their relative position on the string gives the Mendelev number.

If we consider compounds that consist of equal proportions of two elements, we can draw up a structure-map on which compounds effectively separate into regions that can be identified with the different structures that occur. Recently Raimund Podloucky and I have shown that, for metallic compounds, these domains of structural stability derive from the quantum mechanical bond energy and that the classical ionic binding energy has no role to play. This quantum mechanical bond energy depends on the nature of the orbitals that the valence electrons occupy, as the *s*, *p* and *d* orbitals have very different angular shapes. Thus quantum mechanics not only allows us to order the empirical data, by the Mendelev number, but it also explains why metallic compounds take the structure they do.

I believe that during the next 10 years, methods such as these will allow quantum mechanics to contribute to the design of alloys in two distinct but complementary ways. First, we will be better able to order and collate the empirical data on compounds of two or more elements. This will help the designer to interpolate reliably the known data. For example, in the search for new alloys capable of withstanding the high temperatures in jet engines, designers are currently examining ordered Ni_3Al alloys which have the Cu_3Au type of



A microscopic view of the polished surface of an aluminium alloy, magnified 50 times

structure (illustrated by Al_3Li in Figure 1). Ordered compounds with this structure usually get stronger as they get hotter. The structure map should suggest possible candidates for the next generation of high-temperature alloys.

Secondly, quantum mechanics will be invaluable for predicting the energy, structure and mechanical properties of new alloy phases. Currently, metallurgists cannot predict the existence of new structures from the empirical data. For example, General Motors will soon put a new permanent magnet, $\text{Nd}_2\text{Fe}_{14}\text{B}$, in the starter motor of its cars. This ternary compound was discovered recently by chance. No one could have inferred its existence from a detailed knowledge of the neodymium-iron, iron-boron, and neodymium-boron binary phase diagrams. $\text{Nd}_2\text{Fe}_{14}\text{B}$ has a unique tetragonal structure which is responsible for its outstanding magnetic properties. Quantum mechanics, however, could in principle have predicted the existence and properties of this phase. This lies beyond the reach of the current generation of computer programs which are restricted to simple structures. But, extrapolating from the rapid developments in this area in the past five years, I confidently expect the next generation of quantum mechanical programs to be able to predict the existence and properties of such complicated ternary phases.

Very recently, both the US Department of Energy and the European Community have begun to pay researchers to seek new advanced materials—an activity that involves quantum theorists from the outset. Sixty years after Erwin Schrödinger wrote down his famous equation, quantum mechanics is at last taking its rightful place in the design of alloys. □

Dr David G. Pettifor lectures in mathematical physics in the department of mathematics at Imperial College, London.

REVIEW

The wonderful wizard of Menlo Park

THOMAS Alva Edison (1847-1931) was a prolific inventor. The phonograph, and his inventions in quadruplex telegraphy and motion pictures, were highly original. They met market needs and made him a lot of money. His greatest invention, though, was his industrial research laboratory at Menlo Park, New York State. For a few hectic years, a dedicated team worked at the laboratory, sometimes on 40 different projects at a time.

Menlo Park was not like a contract research laboratory of today. No tight, bureaucracy controlled objectives and costs. Edison, the businessman, did not believe in double-entry book-keeping. Menlo Park was an extension of Edison himself, inspired and driven by his desire to invent commercial products.

Edison understood the need to carry his financial backers with him. With a natural flair for publicity, he dramatised his inventions to make their significance clear to all potential investors. So, unlike many inventors, who have died in obscurity, Edison became an American folk hero early in his working life.

Inventive skill, coupled with exhibitionism, won him the title of "The Wizard of Menlo Park" and kept his cash flow positive. Sometimes he would even announce a new invention prematurely. Then, as one of his associates put it: "He would have a full incentive to get himself out of trouble". What Edison did, or was about to do, made news.

Between August 1878 and the middle of 1882, Edison was preoccupied with the development of a practical incandescent lamp and, also, the entire generating and distribution system necessary to deliver electric power into the factory and the home. By 1878 the arc lamp had begun to find some applications, but lighting by incandescence was far from being a practical technology. The fundamental problem—finding the means of heating an element to white heat by an electric current without destroying it—had yet to be solved. And it was only possible to generate electricity on a small scale and somewhat inefficiently. The elements of a power transmission and distribution system were not in existence.

Edison's Electric Light

by R. Friedel and P. Israel, *Rutgers UP*, pp 263, \$27.95

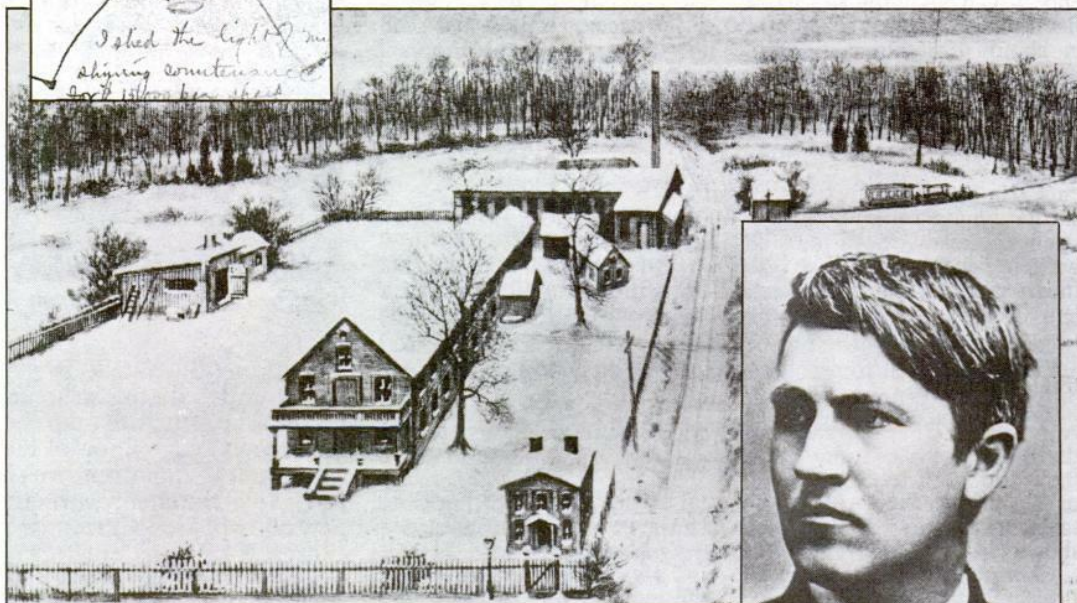
Antony Anderson



The authors, R. Friedel and P. Israel, draw mainly on the large body of archival material at the Edison National Historical Site in West Orange, New Jersey. They reproduce many fascinating sketches, of lamp arrangements and electrical machines, which they have culled from laboratory notebooks. This material shows clearly how Edison's ideas—vague at first—developed with time, and in the light of experience. This level-headed account of Edison's

that any of these men possessed more than a portion of the whole that emerged from Menlo Park as the decade of the 1880's began". These statements do justice neither to Edison nor his rivals. Edison's contribution is, if anything, more impressive when set in context.

The incandescent electric lamp is an excellent example of parallel invention. Edison and Swan worked on the same problem and achieved workable solutions within a very short period of one another. Historians now recognise the joint parentage of the invention. Friedel and Israel give the impression, however, that



Edison's greatest invention was his industrial research laboratory at Menlo Park, New York State. By 1882 he had an electric lamp, depicted here by co-worker, Francis Upton



By 4 September 1882, Edison had developed not only a practical electric lamp with a carbon filament but an entire lighting system. The system was lighting part of New York City.

In stores and business places throughout the lower quarters of the city there was a strange glow last night. The dim flicker of gas, often subdued and debilitated by grim and uncleanly globes, was supplanted by a steady glare, bright and mellow, which illuminated interiors and shone through windows fixed and unwavering... It was the glowing incandescent lamps of Edison, used last evening for the first time in the practical illumination of the first of the districts into which the city had been divided...

Edison's Electric Light: Biography of an Invention brings this frenetic period in history to life.

achievements is a pleasure to read. It is well-researched and free from myth.

However, as Sir Joseph Swan (who invented the incandescent lamp independently of Edison) once said: "Every invention has its pedigree". It is a shame that this book, which the authors claim is a biography of an invention rather than of an inventor, does less than justice to the other main contributor to that pedigree: Swan himself. In the introduction Friedel and Israel say: "It is not right either to make a great deal of the rivals that Edison met in the field, whether in America or overseas and see them as equals in the enterprise". Their grounds are that: "The evidence is simply not there to support the claim

Swan's lamps never worked well and that he did not demonstrate a comprehension of the system requirements of his inventions. This is nonsense.

Swan's lamps worked and he manufactured them on a commercial scale. Swan installed incandescent lamps at Sir William Armstrong's house at Cragside in 1880 (some miniature lamps are still on display there). He fitted out a ship—the City of Richmond—in June 1881, and the Savoy Theatre, London, with a thousand lamps, in 1882. In each of these installations, he took an active interest and supervised much of the work. Shortly after, in the mid-1880s, Edison and Swan joined forces to avoid a debilitating legal battle over

priority. Parchmentised-carbon filament was abandoned and replaced by the vastly superior squirted-cellulose filament invented by Swan. This fact is made quite clear in Josephson's biography of Edison (1959).

In my view, this excellent book is weak on the subject of parallel invention. But having said this, read it, enjoy it, use it as a source of interesting material about Edison and as a point of entry to the Edison

Archive material. To balance the opinions expressed here, I recommend a short article, called "Swan's way: a study in style," by George Wise, historian of General Electric (*IEEE Spectrum*, April 1982). The article contrasts the inventive styles of Thomas Edison and Joseph Swan and allows both these two great inventors a measure of the credit of bringing a working incandescent lamp to the marketplace. □

Voice from Vega

Contact

by Carl Sagan, *Century*, pp 432, £10.95

Marcus Chown

CARL SAGAN says he prefers science to science fiction. He prefers it because science is stranger, more exhilarating, more intellectually stimulating. Despite expressing this preference, Sagan has written a science fiction novel, his first. The novel is about a life-long preoccupation of his, the search for extraterrestrial intelligence. It is called *Contact*.

Contact is an attempt by Sagan to reach yet another audience. He has proved himself an extraordinary communicator of science already, both on the written page and through the medium of television. His excellent books, *The Cosmic Connection* and *The Dragons of Eden* have been read by millions, while *Cosmos*, the TV series he co-wrote with his wife, Ann Druyan, has made Sagan the best known astronomer in the world. So, will *Contact* now make him the best known science fiction writer? On this showing, I have to say, no.

Contact revolves around Project Argus, the search for intelligent radio signals from space, an effort directed by Sagan's heroine, astrophysicist,

Eleanor Arroway. The project succeeds. A message is picked up, from the star Vega, 26 light years distant. At first it seems there is little in the message (except for a rather chilling TV picture) but, in time, Earth's scientists realise that, buried deeper in the radio signal, is a technical manual for the construction of a machine: a kind of spaceship.

The world knuckles down to the immense task of building the alien machine and when it is finally completed a select group of humans, including Ms Arroway, strap themselves in and are spirited off to fulfil their destiny (and that of the human race, the book jacket promises, a little dishonestly) among the stars.

If you have read any science fiction you may have recognised some of the ingredients so far. The radio signal from space, containing instructions to build an alien artefact, appeared in *A for Andromeda*, by Fred Hoyle and John Elliot, the book that became a TV series in the 1960s. The idea of a mysterious alien spaceship over which humans have no control, was the premise

of *Gateway*, by Fred Pohl. Nevertheless, Sagan has come up with one new and thought-provoking twist.

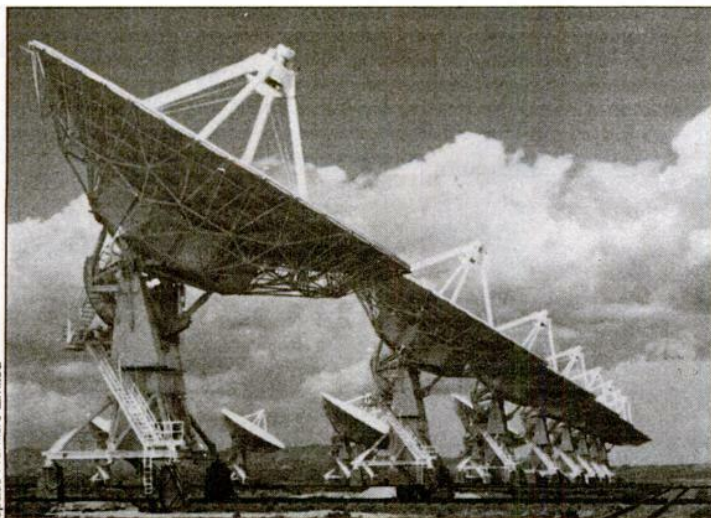
In *Contact* he makes the intriguing suggestion that there is an intelligent message abroad in the Universe which is infinitely more subtle than modulations impressed on a radio wave. Sagan made this point, in *The Cosmic Connection*, when he described the inhabitants of an isolated valley in New Guinea who communicated with societies in neighbouring valleys by the only means they could think of: the drum. All the while the world's vast radio traffic passed around them and through them. It's a vivid analogy. Intelligent messages may be all around us but we are too stupid to see them. In *Contact*, Sagan suggests that we should look in a most unexpected place.

But, one good idea is not enough for a science fiction novel. I expected more from Sagan. Science fiction, after all, is often dubbed the literature of ideas. In *Contact*, ideas are pretty thin on the ground. Having said this, one throwaway idea of Sagan's is particularly amusing. One of his characters has made a fortune from a device which can be fitted to TV

sets. The device, a black box, can recognise advertisements and blank the screen until a bona-fide programme continues. What a neat idea. I wonder if anyone will try and put Sagan's idea into practice. I am sure such a product would be a winner. Mind you, the advertisers might be a little peeved, to say the least.

Sagan also comes undone in his story telling. He admits he has never written fiction before, not even a short story. He has therefore written this novel without serving any apprenticeship. It shows—in the over-and-out dialogue; in the shortage of action to move the plot and draw the reader in; in the long stretches of finger-drumming summary between passages where anything of significance happens.

My impression is that Sagan has taken few risks in writing *Contact*. He has taken on science fiction with tools of a science writer. Impressive though his tools are, they are inappropriate tools for the job. Sagan says he has no plans to write more science fiction. That's a shame. But he is better at communicating the awe and wonder of the Universe through his speculative essays. Long may he continue. □



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ELEGANCE is universally praised, whether in the arts or sciences. In science, however, it is harder to define. The *Oxford Dictionary* defines it as "ingeniously simple and effective". This seems entirely appropriate. Elegance in science is much admired.

My first recollection of Peter Medawar, at a meeting of the New York Academy of Science, is of a man extraordinarily elegant in appearance, in his speech and in his science. The elegance has persisted to this day and is characteristic of his autobiography.

The meetings in New York helped to establish the field of organ transplantation, which Medawar did so much to create. With Tom Gibson, he established the immunological basis for the rejection of normal tissue grafts. The result was confirmed and extended in animals under controlled conditions. It led to the development of transplantation biology as we know it today. With a little help from Ray Owen, Medawar discovered immunological tolerance: the basis for distinction of self from non-self. This was confirmed by the classic experiments of Billingham, Brent and Medawar. They showed that injecting foreign cells into the fetus of mice before birth induced tolerance to foreign tissue. As Medawar puts it: "The real significance of the discovery of immunological tolerance was to show that the problem of transplanting tissues from one individual to another was soluble".

We are now reaping the benefits of this work in the success of kidney, bone-marrow and other transplants in human beings, and there is surely still much more to be done.

For his work on tolerance (perhaps it should have been for his overall work in transplantation) Medawar shared the Nobel Prize in 1960, at the age of 45. His rise to eminence had been meteoric; first, the professorship in Birmingham at the age of 32, then election to fellowship of the Royal Society at 34. It is hard to see how he found the time to develop his interest in philosophy, including, of course, his well known support for Karl Popper and his ideas, but also apparently mastery of Russell and Whitehead's *Principia Mathematica*.

I must confess that, as a practising scientist, I have never felt the need for philosophy. Perhaps I have missed something. Or maybe it is up to each scientist to judge what he or she most needs as a stimulus for scientific discovery. It is appro-

An elegant scientist

Memoir of a Thinking Radish

by Peter Medawar, *Oxford UP*, pp 209, £12.50

Walter Bodmer



priate, however, that the Royal Society's first Medawar Lecture is to be given by Sir Karl Popper.

Medawar's father was a Lebanese who went to seek his fortune in business in Argentina, collecting his wife from a "genteel English family" on the way. As a result, young Peter was sent to Britain for a traditional public school education. This seems to have had three consequences. The first, and obviously the most important, was that he was encouraged by an enthusiastic teacher to take an interest in biology. Secondly, he cultivated a deep love of opera, especially Wagner.

The third consequence was that Medawar reacted bitterly to what he calls "snobismus" — "the irresistible exigent impulsion to appear before the world as someone grander and more important . . . than one really is". This reaction surfaces throughout his book in, for example, his utter distaste for "Blitherington-Smith or Yuppington-Brown"; also in his sensitivity to misdirected anti-Semitism, and the fact that he never actually took his Oxford doctorate. But, of course, Peter Medawar later learnt to turn the tables on snobismus, no doubt revelling in doing so.

Medawar refers to a close school friend as "deeply irreverent", a term which could in many ways be applied to Medawar himself. He can make the most pungent remarks, sometimes in most embarrassing circumstances. The biologist J. B. S. Haldane was, according to Medawar, "the cleverest and silliest man I have ever known".

The full story of Medawar's strokes, and the courageous way

in which, with the tremendous support of his wife, Jean, he overcame them, is most moving. The only bitter note here is the frustration which a rehabilitation centre caused him. According to Medawar it nearly prevented his recovery. How important it can be to have a positive attitude at such a diffi-

cult time, and to have the support Peter Medawar got from Jean. Even a whole chapter hardly does justice to the extent to which she has enabled her husband to continue to be witty and stimulating, for the benefit especially of the scientific and immunological community, while continuing with her own career.

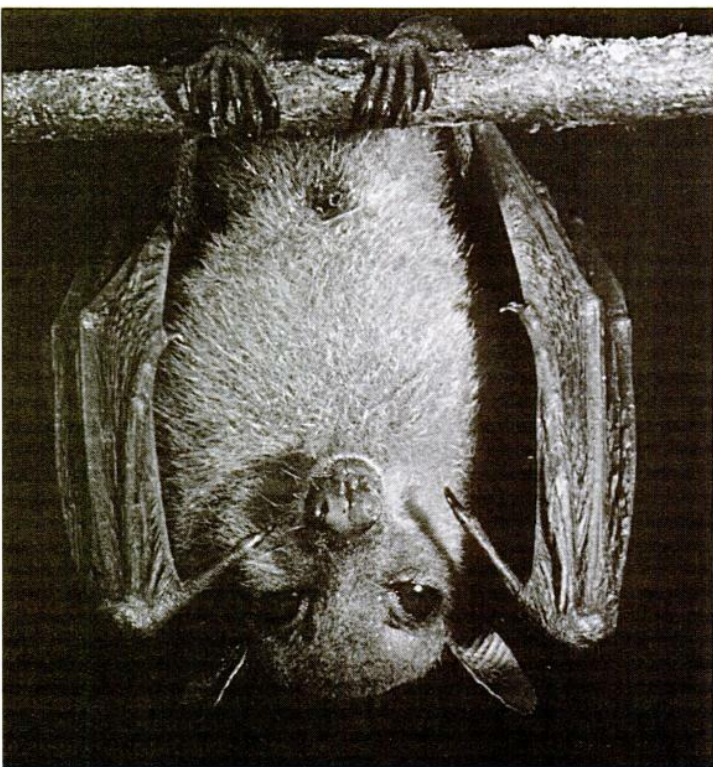
Each reader of Medawar's delightful book will, no doubt, be struck by different parts. I read, with interest, how a university professor must be all manner of things, including psychiatrist; how the head of a large research institute must continue to set an example by his own research. And, further, how dangerous it is to take on too many commitments, even the presidency of the British Association for the Advancement of Science. It was during the meeting when he was president that he had his first stroke.

Medawar's vitality is without bounds. His last chapter is a reasoned and effective case for research on extending the human life span. I can think of no better way to finish than by quoting Medawar himself: "The utterance of last words is a deeply unsatisfactory art-form." □

Bats on a sticky wicket

Bats, a new exhibition at the Natural History Museum, London, to mark National Bat Year. On show until 6 July

Stephanie Pain



Common blossom bat from Queensland, Australia

"IT'S AMAZING how much mileage he got out of those so-called narrow concepts" is Herb Terrace's reflection today on the behaviourism of B. F. Skinner. Terrace's double-edged verdict is accompanied by admiration for the man he served as a research assistant nearly 25 years ago. Skinner may have been wrong in arguing that all behaviour can be interpreted as learned reflexes. But, insists Terrace, he deserves praise for trying to find analytical units in psychology analogous with the atoms of chemistry and the cells of biology.

Terrace was speaking during *Apeing Gestures* (Radio 3, 21 May). This was the last of three programmes in which Colin Blakemore, of the University of Oxford, interviewed fellow professionals concerned with the mind.

The broadcast began somewhat ponderously. Blakemore rehearsed Descartes's views and rebutted behaviourism for drastically underestimating even a rat's knowledge when exploring a maze. He then assured us that most psychologists now believe that animals are not mere slaves to external stimuli but actually remember things. Pet owners may well feel they do not need such assurance. Indeed, the

Four-legged thinkers

most arresting implication of this part of the programme was that some psychologists still do not believe Fido remembers where he hid his bone.

For animal lovers who continued listening after such effrontery, there was a fascinating journey through ideas. The anthropomorphic thinkers (which means all of them) will have been successively disappointed and elated. First, as in *Nim: A Chimpanzee Who Learned Sign Language* (Eyre Methuen), Terrace traced his own progress from belief to disbelief in the possibility that apes could talk to their human trainers. A meticulous re-examination of many hours of videotape had persuaded Terrace that combinations of signs were not as meaningful as they seemed at first. Some were the outcome of subconscious prompting by the trainer. Others—for example, a sequence in which Nim was hoping to get an orange from her human companion—were simply a result of her trying everything she knew.

Terrace extended his criticism



Bernard Dixon

to work with the chimps fostered by Allen and Beatrix Gardner, portrayed in the previous programme. Again, after being persuaded initially that one of them was communicating by using sign language—and following grammatical rules—he had concluded that this was not so. Word combinations that appeared purposeful were really the outcome of random shufflings, as with a Shakespearean sonnet thumped out by a typewriter monkey. Other suggestive evidence included the failure of animals to initiate conversations with sign language, and to make the sort of progress seen when a toddler moves from "breakfast—mummy" to "mummy—eating—breakfast".

The good news for Fido's owner is that Terrace is now certain that animals can think. Evidence to support him comes

from a neat twist on those oft-repeated experiments in which a rat has to locate a piece of cheese in one arm of a maze. Take a radial maze instead (like Trafalgar Square, with eight roads leading outwards) and place a morsel of food in every one of the arms. Even without visual or other clues for guidance, a rat will learn to retrieve each tit-bit. It will seldom visit one arm more than once, and will follow a different sequence on different occasions. Terrace concludes from this that animals are able to construct internal, mental representations of the outside world and reflect upon them. And that is what we humans mean by thinking.

If Terrace is right about chimps not using sign language, psychologists can now study thought without the complication of language. If he is wrong, however, his maze-solving rats and pigeons may be able to tell us exactly how they do it. From Blakemore's guarded comments, I sense that this is a possibility he still entertains too. □

This week's reviewers

Antony Anderson is an electrical engineer with a strong interest in the history of technology.

Sir Walter Bodmer is director of research at the Imperial Cancer Research Fund Laboratories.

IF BATTY instead of Ratty had starred in *The Wind in the Willows*, bats might not be in such dire straits today. But with Dracula as PR man, people have not taken to bats in quite the same way as other small furry mammals. The Fauna and Flora Preservation Society's exhibition shows bats in a new light in an attempt to improve their image.

Bats are the only mammals that fly. A thousand species are scattered around the world, ranging from Kitti's hog-nosed bat, weighing in at just 2 grams, to the largest fruit bat with a wingspan of 2 metres; from the fisherman bat, which angles with its claws, to the pipistrelle, which can eat 3000 insects a night. And of course there is Dracula's role model: the vampire bat, which feeds on blood from cattle.

Vampires apart, most bats do no harm at all, and many are positively useful. They pollinate important plants—bananas, avocados, kapok and balsa, for instance—and disperse their seeds. Some Asian people eat them. In Thailand, whole villages make a living from selling bat droppings, or guano, as fertiliser. Insectivorous bats devour huge numbers of pests. And, more easily appreciated, perhaps, research into bats'

systems of echolocation have led to the development of sonic guiding devices for blind people.

Britain is home to 15 species of bat—just. Our largest species, the mouse-eared bat, is reduced to a population of one. Other species are in trouble too. As forests have given way to vast open fields of crops, often sprayed with pesticides, the bats' insect larder has become depleted, and nest sites in short supply. Many bats have adapted well and moved into more modern homes. But houses are not always safe places. Some people just cannot stand bats and do their utmost to get rid of them. Chemicals used to treat timbers against woodworm are lethal to bats and persist for many years. They are used despite the fact that safe alternatives are now available.

The law is on the side of the bat. It is illegal to kill one and illegal to use poisons where they might affect bats. But until people learn to love bats, they will continue to break the law.

Fortunately, bats are not without their friends. Bat conservation groups the length and breadth of Britain are putting up bat boxes to encourage new roosts. And if you have a problem with bats, give your local group a ring. □



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FORUM

Why cricket is no longer cricket

As a contest, cricket is under threat, says Colin Tudge. Fortunately, it can still be saved

GAMES like cricket and tennis are interesting in part as physical spectacles, like ballet, and in part as contests. Their interest as contests depends upon balance: there is no contest if one side overwhelms the other. Balance is partly a matter of equality of talent, and partly a matter of the way the game is designed.

The men and women who first established modern cricket and lawn tennis spent many a year fiddling with the length of the pitch (or court), the height of the stumps (or net), and the size of the bat (though they did not find it necessary to limit the size of the tennis racquet). Modern cricket and lawn tennis are played at a far greater pace than when they were first devised, and the fact that they are still worth playing at all suggests that their founders did their work well. After all, if the net in lawn tennis were 20 centimetres lower, then the service of McEnroe or Lendl would be quite unreturnable, even by other great players, and the game would be reduced to a procession.

As a contest, however, cricket is now under threat. As played in the West Indies, it crucially favours the bowler. Every year, successive waves of visiting batsmen—Indians, Australians, Pakistanis and Englishmen—trail from the wicket shell-shocked, dispirited, and often physically damaged. The visitors in recent years have not been lacking in talent: the West Indian batsmen themselves do not look especially good when they face their own concerted attack on their own wickets, as they do in part when island plays island. But whereas test teams traditionally include two fast bowlers, plus a medium pacer and a spinner or two, the West Indians now play four fast bowlers of extreme pace. Such an attack, played West Indian style, cannot lose. Unless the laws or the dimensions of the game are adjusted, then it simply will not be worth playing. It isn't a matter of courage, or application, or talent, as the tabloid newspapers like to suggest. It's just a matter of physiology and the laws of physics.

On the face of it, after all, it is not humanly possible to play good fast bowling at all. It takes at least as much time for nerve impulses to travel from eye to limb, and for muscles to contract appropriately, as it takes for a ball to travel the statutory length of the cricket pitch. In practice, however, batsmen don't "react" to bowling.

They anticipate it. They begin their stroke at the moment the ball leaves the bowler's hand, or even before, judging its angle of approach ("line") and position of bounce ("length") from secondary cues: the height of the bowler's arm, the angle of his wrist, the slope of his shoulder. Somewhere in the cerebellum, mathematical calculations of awesome complexity are carried out, which predict the trajectory and the height and angle of bounce off the pitch. If these calculations are done correctly, if the batsman's brain is wired appropriately to his body,

be controlled only partially, such that a bowler may intend the ball to swing away from the batsman late in its flight but cannot precisely control the angle of seam and the relative speed required to achieve this. The element that is not precisely controlled is hardest for batsmen to anticipate, and every now and again a good bowler sends down a delivery that is literally unplayable.

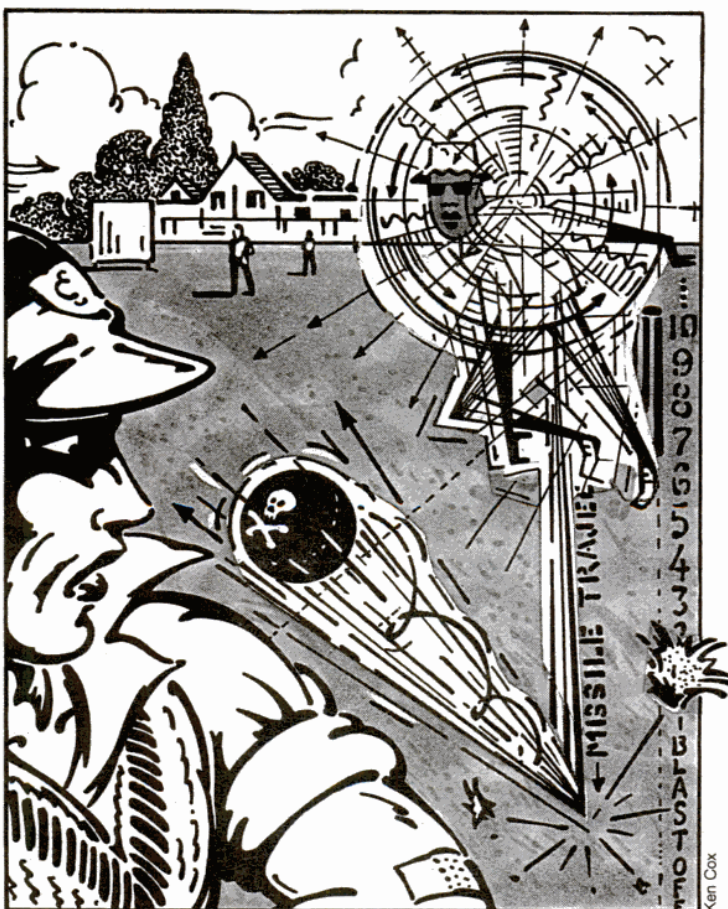
Insofar as the West Indian fast bowlers send down a great many deliveries that are unplayable, and manage to take wickets as a result, the rest of the world can have no complaints. The West Indians are just too good. It would be ludicrous to ask them bowl more slowly, and aesthetically unacceptable to demand that they bowl off a shorter run-up to ensure that they do so. If it is true that they have outgrown the 19th-century dimensions of the pitch, as Lendl has almost outgrown the dimensions of the tennis court, then there is little that can be done.

But the West Indians do not win entirely by talent. There is an element in their attack that is not quite legitimate, and, insofar as that this is the case, it should be put to rights.

The West Indians did not invent fast bowling but they have introduced two crucial elements which give them an advantage that no previous bowlers possessed. First, they hunt in packs—four in a team rather than two. Each fast bowler in a traditionally structured team has to bowl for much longer intervals than the West Indians do today. Secondly, the West Indians now bowl as few as 10 overs—60 balls—per hour, whereas bowlers in 1950s were expected to bowl about 18 overs—108 deliveries—in an hour.

In the traditional game, if and when the batsman tired, he lost concentration and so lost the ability to anticipate the flight and bounce of the ball. But, as the bowler tired, he too lost concentration. Line and length were compromised before mere pace, and so, too, his ability to bowl the unplayable ball. If he failed to dominate the batsman before his concentration begun to wane, then the batsman dominated him. Indeed, part of the skill of the old-fashioned quickie was to pace himself, bowling "tightly", but "within himself", for most of the time, and producing only the occasional burst of well controlled fire.

In short, the balance of the traditional contest was and is partly a matter of talent,



and if his technique is sound, then the arc of the bat does indeed meet that of the ball, and the impossible is achieved.

If the bowling is unvaried, the pitch true, and the batsman good, then such anticipation is all that is needed. Even if the bowler is very fast indeed he will be given a bad time if he does not vary his attack, and so will the fielders whose task it is to retrieve the ball from the far corners of the ground. So good bowlers do introduce variations, of line, length and pace. A great bowler can control some parameters absolutely: he can decide, for example, precisely where the ball will pitch. But the physical laws of ballistics and the limits of human abilities are such that some parameters can

and partly of physical and mental stamina, as in any other sporting contest. The fight is to the contender who tires least and whose concentration survives for longer.

But because the West Indian bowlers hunt in packs, and because they produce only 60 deliveries an hour, they do not tire. The element of personal physical competition between batsman and bowler is lost. It is as if Ivan Lendl were required not simply to play John McEnroe, but had to play McEnroe, Willander and Becker in successive games, with each opponent having a rest in between. The old-fashioned fast bowler had to bulk out his artillery with a proportion of mortar fire, designed primarily to contain the enemy. But the modern West Indians have no need to conserve their strength. Each delivery is an Exocet. To change the metaphor, they wind themselves up for each delivery like an Olympic athlete throwing a javelin.

Again, to object on the grounds that the West Indians have hit a successful stratagem may seem merely petulant. A few Exocets are clearly better than a lot of mortars. But there is a point of principle.

The West Indians win in large part simply by taking their time, and in all games it's accepted that to gain advantage by dragging things out is cheating. If the bowling sides were required by the laws of the game to send down 108 deliveries an hour—with each one less than that conceding a run—then either the West Indian quickies would need to pace themselves as has always been necessary in the past, or else the team would have to play spinners to increase the strike rate.

The alternative notions, widely aired in the press, are almost all absurd. One demands that England and other sides should simply acquire their own packs of neo-Caribbean fast bowlers. If they did, they would indeed win a proportion of matches, but the games would be short and not worth watching. Another demands that batsmen should re-learn the art of batting: but to resist the present West Indian attack is physiologically impossible. The simple truth is that the West Indians are not simply talented, but have found a loophole in the structure of the game. It just needs a little repair, that's all. □

activities were available), although nearly all wanted to. The first 20 minutes or so were mostly sheer experimenting fun—chucking different materials into the water to see which would float or sink. After that, quite a few children were ready to work on a diver.

What an atmosphere! Children moved hither and thither clutching assemblages of materials, trying out, discussing, adapting, trying out again until something worked. Any successful ideas were quickly taken up by others—like four-year-old Esther's idea of Plasticine "anchors" to drag down the too-bouyant polystyrene balls.

Some children gave up, of course, and a few didn't even try, but the many successful divers were rescued and refloated after we had cleared out all the flotsam from the big pool at the end of the session. We had matchboxes with weights in (not too many or they would sink right under), flat balsawood rafts weighted with Plasticine, polystyrene balls stuck with pipe cleaners and Plasticine anchors, a plastic building brick bouyed up just enough by jamming a cork inside. Three-year-old Andrew drew a diver on a piece of rice paper and floated it—it absorbed water but stayed floating below the surface.

We adults were needed, not because the children messed around with the water (there was hardly any mopping up to do except when the bung came out of the paddling pool) but because a great deal of thinking, experimenting and developing of ideas was going on. We were there to discuss and give stimulus at the right moment to keep a good thought going until

it got somewhere. We didn't provide the ideas: the children had plenty of their own.

So what was gained? Well, the enjoyment, enthusiasm and inventiveness of minds applied to a task. Isn't this a fundamental of science—intense curiosity about the physical world, given a discipline and direction by the problem to be solved? Given the chance, small children are natural scientists.

Experimentation is basic to nursery education. During

any normal week our pupils use sand, water, clay, bricks, levers and pulleys. They tip water into bottles and tap them to listen to the varying notes; they shine torches into a light box; they play with Lego models lit by simple electric circuits with switches. They are accustomed to exploring the physical properties of materials they encounter (within limits!); they learn to cope with this freedom and use it as part of nursery life.

How often are school children allowed such experimental scope? Judging by the behaviour of older, even secondary, children who often visit us and join in our activities enthusiastically, very rarely. □

Toddlers take to science

They're born experimenters, says Gill Wrobel

IF SIR KEITH JOSEPH was so eager to promote science in schools—and the evidence makes me doubt it—why didn't he launch a full-scale expansion of nursery education? Marcus Chown was right to point out (*New Scientist*, 27 February, p 55) that five-year-olds are highly knowledgeable about certain areas of science, such as space and dinosaurs, but the real seeds of science—fascination in the physical world and its behaviour—are present earlier still. Nursery schools and classes can provide a terrific environment in which three- and four-year-old scientists can explore and learn.

This goes largely unrecognised even by educationalists. After all, little children spend their time in nursery schools just mucking about with sand and water, don't they? We nursery teachers have come to expect this kind of ignorance, but my blood still boils when a teacher in a secondary school says, "You mean you actually have properly qualified teachers for those tots?"

Perhaps we are oversensitive. But we did feel miffed when our school, Church Hill Nursery, in the London Borough of Waltham Forest, was not automatically asked to take part in the borough's Primary Science Challenge 1986. An oversight? Or yet again the implicit assumption that children are too young for science?

Science Challenge is an annual event in Waltham Forest. The Science Advisor, who oversees science education in schools throughout the borough, devises a small number of scientific problems suitable for the primary age group, which he sends out in a sealed envelope to schools, not to be opened until the week of the challenge (to prevent too much direction by teachers beforehand). Advance notice is given of the kind of equipment and materials which will be needed. When we finally managed to get hold of the details, we decided to concentrate on one question for one day.

Our parents, already intrigued by requests for plastic bottles, foam rubber, nails and expanded polystyrene, looked startled when they brought their children into the nursery one morning to find a huge paddling pool in the middle of the carpet,



Mucking about with water? Or demonstrating scientific skills?

and numerous buckets and bowls full of water dotted around the floor. Was the roof leaking again? One little boy was heard muttering excitedly about swimming lessons.

The problem we chose was: "Make a diver that can float below the surface of the water." We decided not to bother about achieving realistic-looking divers—any object that the children could get to float in the required way would be fine.

All the materials had been set out on tables: the "diver" challenge was explained to 40 expectant faces, and they were set free to experiment. No one had to join in for all or even part of the session (alternative

Pete Addis

An ill wind blows patients some good

The cash crisis could aid diagnostics, says Bernard Dixon

"**I**LL BLOWS the wind that profits nobody," Shakespeare insisted in *Henry VI*, Part 3. We should, I think, assume that the adage was another example of the Bard's uncanny universality, and that he did not have specifically in mind the effects which cash limits imposed by Margaret Thatcher's administration were to have on tests carried out under the National Health Service 400 years later. On the other hand, the adage seems remarkably appropriate in this context. For while doctors and other staff protest about the parlous financial state of the NHS, that selfsame cash crisis could be bringing unnoticed benefits for diagnostics.

To be more precise, penury is likely to accelerate changes which are afoot already, and which may partly reverse a major shift in routine testing that began three or four decades ago. Until that time, family doctors and hospital clinicians were quite accustomed to messing about with test tubes and chemicals. Dr Finlay would know exactly how to fix a smear of Mr McGinty's faeces, stain it with methyl violet, add iodine solution, decolourise with acetone, counterstain with basic fuchsin, and then peer at the slide under a microscope to see whether Mr McGinty's intestines were teeming with *Salmonella typhimurium* or just *Escherichia coli*. Such things were done in a trice, while Mr McGinty sat in the consulting room admiring his doctor's wizardry. No technicians. No forms. No "Come back a week on Tuesday for the result".

Likewise, even the most junior physician in a District General Hospital could step from his ward into what was then called a sideroom, and perform a Paul-Bunnell reaction for glandular fever, a glucose-tolerance test for diabetes, or a Ziehl-Neelson stain for tuberculosis. Some tests were even done at the bedside. Only the most complex investigations required the services of a centralised pathology laboratory. One great advantage of do-it-yourself methods was that you could do-it-yourself at 3 am if need be.

A decade or so after the inception of the NHS, however, all of these convenient but amateurish efforts were swept away. The work was incarcerated instead inside specialised laboratories, which soon began to rival Jodrell Bank in their hum of efficiency. Automated analysers and other ingenious equipment arrived, leaving ordinary doctors with no role in diagnostic testing other than to mark their requests in



Testing times. Drs Finlay and Cameron had some usefull skills

triplicate on pink, yellow and green requisition forms. Science had triumphed. And the advantages were obvious in the standardisation of screening procedures and their improved accuracy, sensitivity and reliability.

But there were demerits too. Above all, a generation of young quacks innocent of laboratory lore started to demand tests willy-nilly, ticking dozens of options simply because they were there on their dockets. Wodges of data began to return from laboratory benches, yet had no effect on the care of patients. By the early 1970s, this indefensible waste had begun to attract obloquy and ridicule. The hard facts were bad enough. Dr John Hampton and a group of fellow vigilants reported that more than 90 per cent of diagnostic tests carried

out for one outpatient clinic had no influence whatever on the diagnoses which doctors made by examining their patients and asking them questions (*British Medical Journal*, 1975, vol 2 p 486). A few years later, Dr Gerald Sandler found that the results of tests contributed to less than 1 per cent of diagnoses in another clinic (*BMJ*, 1979, vol 2, p 21).

By then, however, Shakespeare's ill wind was getting up, and has since freshened to hurricane proportions. One result, apparent over the past five years, has been the appearance of several papers demonstrating that laboratory tests can be reduced drastically—without risk to patients but with unquestioned merits for hospital budgets. A few months ago, for example, Dr Francis Fowkes and colleagues reported (*BMJ*, 1986, vol 292, p 883) that they had been able to prune biochemical assays by 64 per cent in one teaching hospital unit, simply by providing doctors with guidelines and reviewing medical records each week.

So, indiscriminate testing is being curbed on grounds of common sense. But I detect signs of another trend too—a return to do-it-yourself habits in the sideroom and surgery. The change is being made possible by further innovations in biomedical technology. While sophistication in the 1960s meant the centralisation of expertise and gadgetry, today it means the simplification and miniaturisation of tests that can be carried out at the bedside.

Anyone who has wandered around a biotechnology exhibition recently will have been struck by the emergence of quick, easy-to-use techniques for detecting disease-causing microorganisms in blood, sputum and other fluids. Latex agglutination kits, for example, permit pathogens such as *Haemophilus influenzae* to be identified rapidly and unambiguously from visible precipitation reactions. Dipsticks are available to reveal white blood cells in urine. Other methods now being adapted for "patientside" application include DNA probes and circular intensity differential scattering—which, despite its grandiose title, permits pathogenic bacteria to be identified remarkably easily according to how they scatter polarised light.

I am no more convinced that Margaret Thatcher consciously encouraged these developments than that Shakespeare anticipated them. For the moment, too, some of the new kits are comparatively expensive. But, in the long-term, allied to more prudent use of necessary laboratory facilities, they seem poised to cut very satisfactorily the NHS's present over-expenditure on biochemistry and microbiology. They should also aid good doctoring. It was always a daft idea to isolate science from the human touch. □

ENIGMA

No 361

How many furlongs to the mile?

by Ian Adamson

"**H**OW CAN one inch, one foot, one yard, one furlong and one mile be only 249 inches?" asked Albert, who was looking at a calculation in the Tarzanian University library. "Simple," replied the librarian. "That sum was done before we adopted the English system of metrication."

"How many furlongs to the mile were there?"

"Perhaps you would like to work out that prime number if I tell you that there were more furlongs to the mile than yards to the furlong, more yards to the furlong than feet to the yard and more feet to the yard than inches to the

foot, said the librarian." What is the answer to Albert's question?

A £10 book token will be awarded to the sender of the first correct solution opened on Thursday, 12 June 1986. Please send entries to Enigma No 361, New Scientist, Commonwealth House, 1-19 New Oxford Street, London WC1A 1NG. The Editor's decision is final. The winner of Enigma No 358, "Add up the scores", was John Szymanski, of York.

Answer to Enigma 358

Add up the scores

(i) A v B, 1 - 0; B v C, 2 - 2; A v C, 0 - 0; B v D, 2 - 1; A v D, 3 - 0; C v D, 4 - 4.

(ii)
4 2
5 4
9 6

A letter to Chas 'n' Di

Bob Ralph asks a favour of the Prince and Princess of Wales

SOMETIME just before Christmas I did something I have never done before: I wrote to the Prince of Wales. The letter was prompted by speculation in the newspapers that his wife was expecting a third child—unfounded speculation, as things had turned out.

I took great care to find out just how to write to the Prince, addressing my letter to his Private Secretary, asking him to bring the subject to the Prince's attention. I received a courteous reply from Sir John Riddell, Private Secretary to Their Royal Highnesses, saying that he would lay my letter before Prince Charles as soon as possible.

Well, to date I haven't had any further reply and it looks as though the letter has been overlooked. I can hardly say I'm surprised, and I'm not particularly upset about it, given the crushing work load heaped on the man and his wife. In fact, I had forgotten about it, and only thought about it again when Princess Diana fainted momentarily and all the speculation began again.

The letter went something like this:

Your Royal Highness,

I am a university lecturer in zoology and for many years have been concerned about conservation in its widest aspects. I know that this is an area of interest to you, and I'm sure you have been influenced by your father who has spoken and written on the subject very sensibly on many occasions. Indeed, his speeches and his high profile on the subject put many professors and other academics to shame. So many academics seem to be afraid to speak out about the way the world is going.

I don't see any signs for optimism in our relationship with the natural world. In fact, I am afraid we are losing the battle, the battle so clearly laid out in the World Conservation Strategy (WCS): to maintain the essential bio-geochemical recycling systems that we depend on, to preserve the genetic diversity of the natural world, and to maintain on a sustainable yield basis our exploitation of renewable resources, forests, fisheries, agricultural systems and the like.

It is to the credit of the people who drew up the WCS that the thousands of problems facing us in our relationship with the world could be summarised with such an economy of words. Sadly, although the message is clear, it is either so unpalatable, or the magnitude of the tasks involved is so great, that it is not getting through.

When it comes down to it, whatever one's cause is today, it is a lost cause unless we control population growth. Here in Britain and the rest of the developed world, most of us still think of overpopulation as someone else's problem, because we are still rich enough to be able to buy the resources that we use.

I am appalled at the inevitability of the

population of Africa doubling in the next 30 years. What kind of BandAid, LiveAid, SportAid, will we need then? The government of Kenya, faced with a population growth rate of 3.8 per cent, has introduced a new policy hoping to reduce population growth to 3.3 per cent by 1988, a drop in the average number of children per family from eight to six!

Since I was born in 1941, the population of the world has doubled; if I should make it to an allotted three score years and ten it will have doubled again. We are not coping at present; what chance will there be a generation from now?

In Britain, the size of one's family is still a personal thing, but several years ago my wife and I took the decision to have only two children. I can talk to students and to anyone else who will listen to me about population growth, but my platform is a limited one. You are obviously in a much better position than I am to influence and shape public opinion—after all, I am not likely to have 20 minutes in which to bend the ear of the Pope. I urge you to consider

limiting your family to the two children that you have and to speak out and say why, so that the urgency of the problem of world population growth might begin to percolate into people's minds.

In all his speeches and writings, I feel that your father has never spoken out as strongly about population control as he has about other topics. With four children, he would be an easy target for the critics. After all, the tiger that he didn't even shoot is still an albatross round his neck.

Yours respectfully, Bob Ralph. □

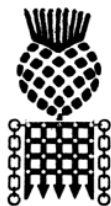
PERHAPS THEY'RE GOING FOR A POLO TEAM...



Did star wars shake up the Cabinet?

Strange goings-on at Westminster

THISTLE DIARY



Tam Dalyell MP

WORD IS about that a testy Margaret Thatcher told both Leon Brittan and Michael Heseltine, at the beginning of December last, that the Strategic Defense Initiative (SDI) programme was her agreement with

President Reagan. If they did not like it, she said, then they could leave office. Which, of course, they subsequently did.

In politics, the flashpoint sometimes comes on issues, ostensibly central, but which in truth are not the real cause of ministerial blow-ups. It happened between Harold Wilson and George Brown, on the Middle East, in the 1960s.

I believe that Michael Heseltine's actions in resigning were fuelled far more by his being made to accept an SDI programme than by a £30-million helicopter company. Heseltine and many senior civil servants in the Ministry of Defence were highly sceptical of star wars in any form.

At least, this scenario explains why, when I went to Yeovil on 18 November last, Westland's managers complained that they could not get Heseltine to display the slightest interest in urgent problems.

EVERY CELL in our bodies contains over 2 metres of DNA (billions of miles in a whole person), and within this enormous length are many thousands of genes. These genes are really instructions, written in the DNA code, that specify the chemical processes needed for life. In a normal indi-

vidual, all the genes are carrying the right instructions. We know, however, that many of our most debilitating and incurable diseases, such as haemophilia, cystic fibrosis, muscular dystrophy and cancer, are due to defective genes. In 1972 the Medical Research Council set up, in Edinburgh, a Mammalian Genome Unit (MGU) to study the genetic material in humans and other animals. Now the MRC seems to want to close the unit.

Although the MGU has been committed to solving many long-term problems, its work has produced several spin-offs that are already benefitting biotechnology and medicine. Best known is the "Southern blot" which is now used all over the world for antenatal diagnosis of genetic diseases. More recently, the MGU has devised tests for sexing human embryos, allowing early identification of those at risk for diseases carried by the X-chromosome. In addition to its research, the MGU has served as a centre for training in advanced techniques, including, for example, genetic manipulation of plants and farm animals.

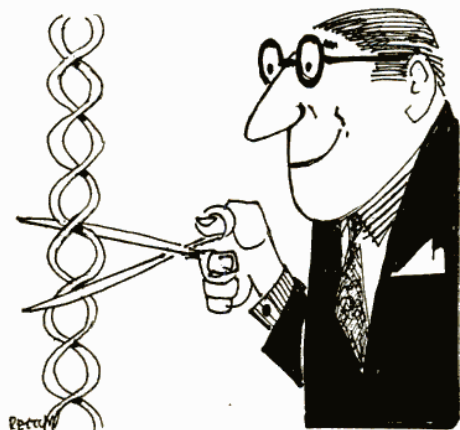
The MRC's decision to close the unit, it seems, is being taken purely on the grounds that a new director, of the calibre needed, cannot be found. This the staff at the unit totally reject. The person acting as director was interviewed for the job, did not get it, but was almost immediately promoted by the MRC to a post equivalent to a directorship.

Many of the staff at the MGU claim that the MRC has made a political decision to close the unit to try to save money, and is simply using the pretext of being unable to find a director as the reason for this closure. Indeed, the council may have manipulated the situation to achieve the closure, as ►

Bob Ralph is a senior lecturer in zoology at the University of Aberdeen.

► it could not do so on any other grounds. Hitherto, the MRC's own reports have been highly complimentary of the unit's work.

If this unit closes then considerable expertise in a new technology will be dissipated. Staff will be left with no alternative but to go abroad in many instances (the unit has a high international reputation); their talents will be lost to Britain. Unfortunately, some have already gone.



FIGURES speak more eloquently than words. Through a question addressed to the Secretary of State for Education and Science, Austin Mitchell, Great Grimsby's interrogating MP, extracted the figures for the number of 18- to 25-year-olds in higher education as a percentage of their age group: United States, 61.2; Japan, 34.2; France, 34.1; Britain, 30.1. That just about says it all!

ALERTED by a news item in this journal, I raised with the Scottish Office the issue of planning permission for the proposed facility for the fabrication of pipelines at Morrich More near Tain, on the Dornoch Firth, in northeast Scotland. I am glad to learn that Malcolm Rifkind, the Secretary of State for Scotland, is calling in the application for his own determination. Michael Ancram, the minister of state, tells me that there is likely to be a local public inquiry. It will thus be possible to explore fully all the issues before Rifkind makes a final decision. Would this have happened, I wonder, if *New Scientist* had not blown the whistle?

TEACHERS are beginning to ask MPs about the National Educational Resources Information Service. John Butcher tells the House that this is a computer-based service for schools that provides information about educational resources, and is designed to assist teachers. The service is an interactive one, and, provided schools have modems attached to their microcomputers, they will be able to gain access for the cost of a local telephone call. The Department of Trade and Industry is financing the service for three years and it will be available from January 1987.

Butcher is a young minister and quite rightly an earnest one. However, I am not sure his colleagues are completely convinced about the value of this latest gadgetry. For my part, I shall be curious to see how much the service is used. Let us wish it well.

OUR WONDERFUL FEEDBACK

pharmaceutical industry is boosting its image with a television commercial shot in an empty tuberculosis clinic. The message: pharmaceutical advances did away with tuberculosis, so the drug industry can do the same for cancer, if it is allowed to make enough money.

This is no place to decry the efforts of those who developed drugs to end TB's reign of terror. But does pharmaceutical research deserve all the credit? A look at statistics from the Office of Population Censuses and Surveys suggests otherwise.

In 1850, tuberculosis accounted for 60 385 deaths in Britain. This was 16.4 per cent of total deaths. In 1940, tuberculosis killed 27 871 people, and accounted for 4.9 per cent of all deaths.

The great biochemist Selman Waksman did not isolate streptomycin until 1943, and it did not become available in Britain until much later. True, in the years since the Second World War, the percentage of deaths that tuberculosis causes has fallen to 0.1 per cent. But as for most of the great Victorian killers, the main decline in deaths had more to do with better housing, sewage and diets than with pharmaceutical research.

Incidentally, tuberculosis still kills some 600 people a year in Britain, mainly immigrants from the Indian subcontinent.

THE DRUG industry has no monopoly on medical bullshit. The World Health Organisation in Geneva startled observers last week with the announcement that it had decided to become "the Vatican of immunisation".

The reason that immunisation needs a Vatican has more to do with United Nations politics than with saving people's lives. The success of the UN children's fund, UNICEF, in raising support and publicity for vaccinations has put some rival noses at the World Health Organisation out of joint.

The WHO wants to declare next year "World Immunisation Year", in order, say Feedback's informants, "to stake out its own turf in immunisation" and to "remind everybody that the idea really started with WHO". Aaah.

OUR MAN with the hardware incompatibility needed to convert a 25-pin plug (male) to a socket (female). After a fruitless trapeze round the electronics shops, he wearily explained his requirement yet again. "Oh yes," replied the sales assistant, "what you need is a gender bender," and promptly supplied the demand.

NICHOLAS RIDLEY, Britain's new secretary of state for the environment, is well to the arid wing of the Conservative Party, one who makes the Sahara look like the Somerset levels.

However, Ridley's effect on the environment will not be quite so dramatic unless he improves his grasp of detail. One of the main tasks in his new job is the distribution of government grants to local councils to relieve the rates.

The system is known as the rate support grant, or RSG for short. Once during a briefing for journalists on bus subsidies, the

subject of the RSG came up. Ridley thought it stood for the revenue support grant.

At least he will have no trouble in finding his new job. On his first day in his previous job as secretary of state for transport, Ridley turned up at the Westminster office block shared by the environment and transport departments and went to the environment door. Only to come out shamefacedly a few minutes later.

Another imponderable is how Ridley will get on with his junior ministers. Take Sir George Young, for example, who was thrown out of the Department of Health and Social Security for his anti-smoking views. Ridley is a heavy smoker.

WHEN SONY launched its first portable compact-disc player a year or so ago, someone walked off with the priceless pre-production prototype while the press ate lunch.

The company was taking no chances last week. It booked the Chelsea Barracks in London to show the trade its latest wares. One new product was a pocket television set as small as the one Sinclair makes, but with much clearer pictures.

Sure enough, despite the military security, someone had nicked the television within half an hour of it going on show. However, Sony's other new toy, a solar-powered portable cassette player, went untouched. Although the machine is a big hit in sunny Japan, it may not find as many takers in rainy Britain.

OCCUPATIONAL diseases of our time, number 72. At a recent gathering of molecular biologists, Feedback spotted what looked like a genuine case of "Gilson's thumb".

Apocryphal among gene splicers, the affliction is a sort of tennis elbow for scientists. It gets its name from a piece of apparatus at the forefront of genetic engineering: a thumb-operated automatic pipette often known in the trade as a Gilson.

Cloning or sequencing DNA means hours of sweated labour over a hot Gilson. Sadly, the inflamed tendons of this particular genetic engineer met with little sympathy from colleagues. "Just needs to oil the Gilson," one of them muttered.

AN AUSTRALIAN friend was recently hired as an adviser to a scheme that involves clearing large areas of bush by setting fire to it. On arrival at Darwin airport, he was bundled off to the local television station, to be confronted by local environmentalists.

"What about the wildlife," the activists demanded, "the dingoes, the buffalo, the wild horses?" Our friend pointed out that Australian wild animals know all about fires, and would easily keep clear. But he admitted that there might be some casualties among snakes and lizards.

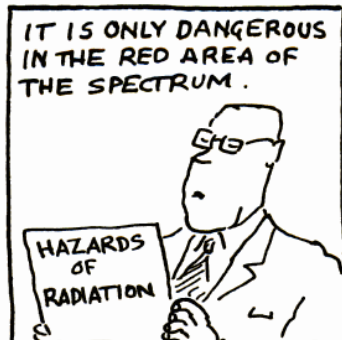
"Oh," said one self-styled environmentalist, "bugger the snakes and lizards!"

LETTERS

Manipulated news

We respond briefly to your excellent commentary article entitled "Nuclear propaganda" (8 May, p 16).

The anti-Soviet hysteria which you mention is not restricted to the US, it is very noticeable in West Germany too. Living in Bavaria for the past three years, my wife, having the French nationality and I, a Dutch citizen, could take a somewhat more critical view of the news as it was brought by the German radio and television. What struck us most over the past few weeks was the extremely biased way the news about the accident at the Chernobyl nuclear plant was reported.



We found it especially ironic that a country that boasts of being part of the free West accuses in strong words the USSR of not having given any information to the world at large, and to the Soviet population in particular, and applies the same strategy by not informing its own citizens about the possible hazards. Instead, statements are constantly made about the harmlessness and benefits for the environment of the use of nuclear energy. In fact, it proved instructive to listen on the same day to the German and the Austrian news—the latter being much more open and giving factual information.

We don't write this in defence or support of any of the existing political systems. We would just

like you to know that the anti-Soviet hysteria is not pushed by the US alone. To us, the incident has shown clearly how news can be used to influence public opinion. It is amazing to see the readiness with which official government statements are accepted by the general public and how people can be manipulated. It is easy to find a parallel in recent history.

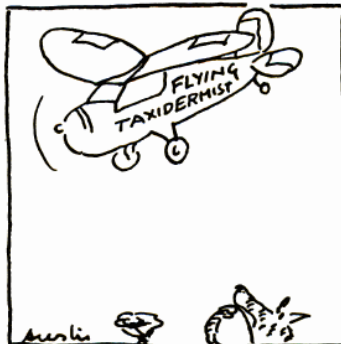
*Elias and Giora Brinks
Garching bei Munchen*

Catch one if you can!

Athol M. Douglas's article on the possible existence of thylacines in Western Australia ("Tigers in Western Australia?", 24 April, p 44) had us checking the date of *New Scientist* to make sure it wasn't 1 April. Like most zoologists we hope that somewhere some thylacines have survived but suspect that the Tasmanian forest is the best place to be looking. It may well be that thylacines are alive and well in Western Australia, but we find it hard to believe that anyone can be taken in by the extraordinary photographs.

We are told that the animal photographed was busily engaged in digging at the base of a tree. The first photograph, claiming to show a thylacine just visible in its centre, requires an act of faith to see anything at all. The best we can make out is a curve, presumably meant to be the back of the animal, at the base of the tree. We find it curious that the discarded rifle should be visible in this picture. There is no information on the focal length of the lens used but we find it difficult to imagine anyone laying down a rifle to take a picture of a distant animal and managing to include that rifle in quite sharp focus. Did Kevin Cameron, the tracker who took the photographs, lay down his gun and then step back the two or three paces needed to include it?

The two photographs that show the animal more clearly look as though they were taken from



positions about three or four metres apart. How long would it take to move that much closer? Given that a great deal of care would have been taken, let's say that it took 5 seconds, probably more like 10. How extraordinary that, in that time, a busily digging animal hasn't changed its posture, the curve of its back, or the angle of its tail, by the slightest amount. A cutout of the shape of the animal in the bottom photograph can be superimposed exactly on the shape of the animal in the upper picture, and vice versa.

The photograph of the last known thylacine at Hobart Zoo, and the picture of the carcass of the unfortunate kangaroo, give clear examples of what fur looks like. In the two photographs showing the "thylacine" digging at the tree the definition of the bark of the tree and the grasses around is first class. Why then does the supposed thylacine look so furless, so smooth, so unreal? When the animal was disturbed by the final click of the shutter, did it react so quickly, bound away so rapidly, that another picture, however blurred and out of focus it might have been, wasn't possible?

The stories of the tracks, the kangaroo carcasses, the doubt over the age of the thylacine corpse found near Mundrabilla Station are intriguing indeed. Cameron would serve his cause better by putting away his scruples and his camera and using his gun. Just one bloodied corpse would settle the matter, and would get him all

the money and conservation support he needs.

*Bob Ralph
Hilary Fry
University of Aberdeen*

I read Matt Webster's comment on the authenticity of the photographs of the Tasmanian tiger (Letters, 15 May, p 76) and then took a closer look at those photographs. I now believe that the apparent movement of the shadow of the tree can be explained by the movement of the observer (to the right), and not the sun. All the features in the photographs are consistent with such a change, although it would have been more natural to move to the left to follow the tiger around the tree.

Secondly, since the photograph was taken in Australia, the shadow of the tree will move from right to left as seen looking in the general direction of the shadow, that is to say south. This is the opposite to that suggested by Webster.

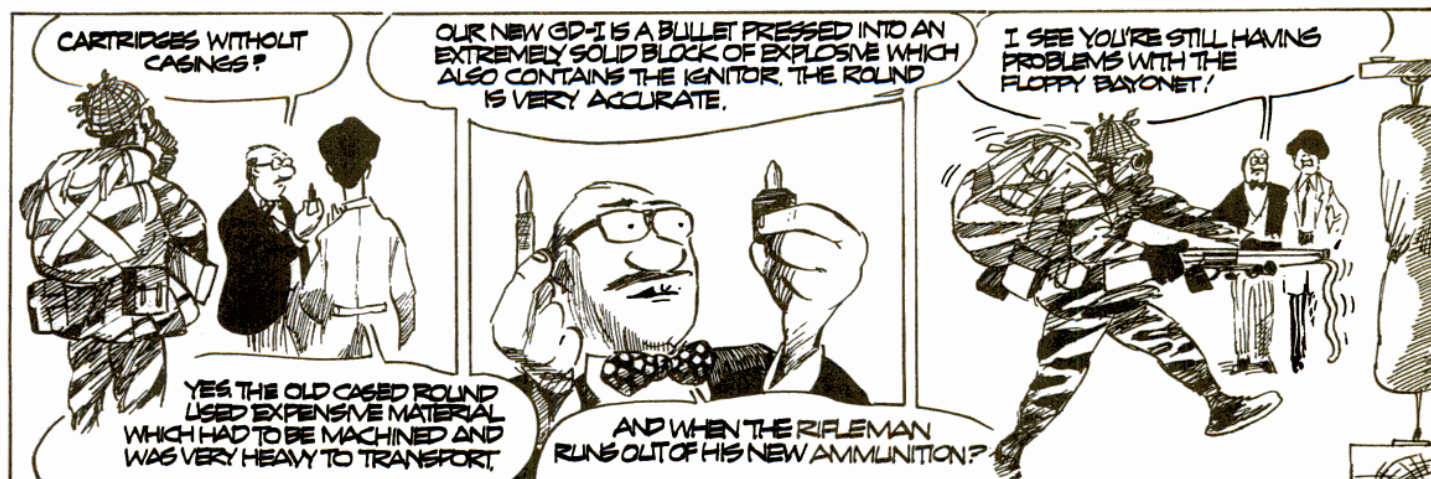
I remain convinced of Kevin Cameron's integrity and of the existence of the Tasmanian tiger!
*L. M. Newell
Ipswich
Suffolk*

Human combustion

John Heymer (Forum, 15 May, p 70) will no doubt assume that I am suffering from the "Lavoisier Syndrome" if I disagree with the conclusion he had reached from his meticulous observations. His mistake is in trying to draw a parallel between the extensive burning to the body which he examined and the processes of cremation, when they can be distinguished by one critical factor. Cremation is intended to destroy a body in the shortest possible time and is therefore carried out under extreme conditions, but a relatively small fire can consume flesh and calcine bone if it is allowed to burn for a long time.

This process, which I prefer to

GRIMBLEDON DOWN



Bill Tidy

call prolonged human combustion, is usually fuelled by fat rendered from the body by the fire. It is no coincidence that in many of the cases this unit has encountered the victim was obese, and there was always a long delay before the fire was discovered. Examples of prolonged human combustion are, admittedly, rare but this should not be taken as evidence that an unusual source of ignition is involved. Indeed, all cases investigated by this unit have been resolved to the satisfaction of the courts without recourse to the excuse of "spontaneous" human combustion.

D. J. X. Halliday
Fire Investigation Unit
The Metropolitan Police Forensic
Science Laboratory
London SE1

Improbable phenomena tend to elicit improbable explanations, *faute de mieux*. Assuming the phenomenon of spontaneous human combustion to exist, it would require a combustible body, a zone of relatively high ignitability, and an ignition source.

Obesity and dehydration would tend to favour the first of these requirements, and the consumption of great quantities of liquid paraffin, which habit I believe still survives among the constipated elderly, would add to the overall fuel content of the body and, as is known in the case of over-consumption, of the underwear and cushion.

Anaerobic fermentation within the gut, as is perhaps favoured by paraffin encapsulation of its contents, produces sometimes prodigious quantities of inflammable gas; consumption of eggs, for example, which are especially rich in phospholipids, might well add, to the normal methane and hydrogen, significant amounts of phosphine, and, worse, phosphorus dihydride, thereby imparting to the gas the property of spontaneous inflammability—the dreaded phosphoric fart. (How many of your readers have attributed singed underpants and burning thighs to mere frustration or, while strolling on a warm summer night after a second *soufflé*, have observed their breath glowing?)

Autooxidation of lipids leads to the formation of peroxides, the decomposition of which is no doubt involved in the spontaneous combustion of oil-impregnated rags. Postmortem body temperatures as high as 43° Celsius have been reported within hours of death, possibly as a result of similar reactions. Were it to come about that morbid reservoirs of peroxidised short-chain lipid—or even of ketonic bodies generated by a disordered metabolism—accumulated, their endogenous oxygen might explain the precocious burning away of the torso which John Heymer describes.

Sidney Alford
Explosives Engineering Consultant
Corsham, Wiltshire

Embryo research

The description which Anne McLaren gives of the early development of the human embryo ("Why study early human development?" 24 April, p 49) is, to say the least, misleading. The embryo does not develop after 15 or 16 days within a clump of distinct "life-support systems" cells. These cells are part of the embryo and develop, as do the cells of the primitive streak, from the fertilised ovum, with the full genetic complement of the embryo. The genetic information for the differentiation of every system of the body is contained in the nucleus of the totipotent fertilised ovum, and the structures which McLaren regards as the "pre-embryo" are specialised organs in just the same way as the heart and lungs will be later in development.

To try to use such a misrepresentation of the truth as the justification for experimentation on the embryo is unethical. I can only hope that McLaren has attempted to do so out of a genuine failure to appreciate the facts, rather than a deliberate intention to manipulate them.

Hugh Thomson
Western General Hospital
Edinburgh

I enjoyed Anne McLaren's article, "Why study early human development?". However, when she writes, as one of three points supporting in-vitro fertilisation (IVF) research, "if safer, more effective, more acceptable contraceptives were available, the number of induced abortions would be nothing like the present figure of 125 000 a year," she appears to have misconceived, and possibly misused, the reality!

There are a number of safe, effective contraceptives available—125 000 induced abortions a year does not reflect contraceptive failure nor even ignorance, but its lack of use by a substantial section of society.

I agree with her view that pre-embryos destined for uterine transfer should not be experimented on, but for differing reasons. If, during the course of an experiment, a long-term physical or mental advantage were accidentally conferred on a set of embryos it might become unethical, in a caring society, not to offer other embryos that same advantage.

Janet Riley
Royal Gwent Hospital
Newport
Gwent

Anne McLaren says "for most people a pre-embryo is not a person". Perhaps this is because most people have not realised the key discovery of modern science: that from the moment of conception to childhood the development process is essentially continuous; the only real change occurs at conception, and it is

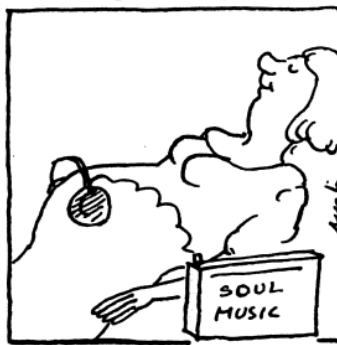
from this point that the human person must be assumed to exist. If the new-born child has rights then the pre-embryo has rights, and the most basic right of all is the right not to be deliberately attacked.

These rights can never depend on the intentions of other human beings—McLaren rather implies that if we intend an embryo to be used experimentally it has no rights but if we intend it to live then it is entitled to full protection. What a responsibility falls on those scientists who create embryos specifically for research!

So many discussions around the Warnock report consider every point of view except that of the embryo and of the child it has the right and potential to become. The human embryo is human life and is not to be treated as a means to an end—no matter how pressing or heart rending that end may be.

Christopher F. Carter
Wootton
Northampton

The excellent articles published in *New Scientist* support and illuminate the scientific case for conducting research on embryos, and I am sure many readers support it. However, the main opposition to research on embryos is being expressed in non-scientific terms and it may be necessary for supporters to address the problem in these terms as otherwise the scientific argument may be lost.



Of the various arguments against this research probably the most fundamental is that killing an embryo amounts to killing a human being. This is based on the allegation that the soul enters the body at the moment of conception. In general, scientists are unable to meet this argument since a soul cannot be described in any scientifically useful way. But following recent articles on some fairly indescribable subatomic particles, I perceive that one can talk about these things in terms of their impact on the observable world.

In brief, I suggest that it makes no sense to suggest that the soul enters at conception, but it makes a lot of sense to suggest that it enters at around the time of birth. So what, then, is an embryo? It looks and behaves like a construction being assembled ready to receive a soul. But it is known that the method of construction is unreliable and that only a minority of conceptions achieve full term as live births.

The failure or natural abortion

of something like two out of three conceptions suggest that nature, or God, has provided a quality control to try to ensure that unsatisfactory constructions are not used. One cannot accept that these failed conceptions each has a soul allocated which is then frustrated. It seems much more likely that entry of the soul is delayed until the construction has passed a final acceptance test, which, I suggest, could be an ability for life outside the womb.

Thus an embryo is not yet a human being and killing it, or causing an abortion, does not amount to murder. But a late abortion with a well-formed fetus must sometimes look like murder. That is to say, it is an unpleasant operation to carry out, its use should be in the position of last resort and the necessity for it reduced by using other methods of contraception.

One may conclude that there is not a moral objection to killing an embryo but there is an objection which could be described as aesthetic which increases with the growth of human features in the later stages of the embryo and fetus. Therefore research in these later stages appears unacceptable.

One might wonder if avoidance of all features, even the primitive streak, is not unduly restrictive. But it does seem clear that responsible and humane research at the featureless conceptus stage does not involve either moral or aesthetic objections.

W. S. Robertson
Stafford

Devastating losses

The conclusions of Julian L. Simon's article "Disappearing species, deforestation and data" (15 May, p 60) came as no surprise to me; not because I have little faith in the calculations of conservationists, but because I have no faith at all in Julian L. Simon.

Simon's view—an oft-repeated one, that there is no significant tropical deforestation—is totally at variance with forestry leaders in the Third World, who can see their forests disappearing, and who are often at a loss just what to do. Indeed, foresters and the government in the Philippines are planning their industry on the basis of their islands being almost completely deforested within a decade or so. The reason that Simon appears oblivious to all this is that he shows little desire to go and see the damage for himself, protesting that on-the-ground research is not necessarily as valuable as scrutinising data in the US.

Simon really ought to think again about who is genuinely responsible for the poor research. It is the likes of Simon who should be taken to task, not the conservationists.

Kieran Mulvaney
People's Trust for Endangered
Species
Godalming
Surrey

Julian Simon could find plenty of answers to his questions in the professional literature. Herewith a few items, by way of illustration.

He cites my 1979 book at length, objecting that it does not present enough evidence of tropical deforestation (and hence of extinctions). Yet he overlooks my 1984 book (he was sent a copy) that presents deforestation details in the form of satellite imagery for 72 per cent of the biome. Remote sensing supplies evidence that is eminently objective and systematic, complete with time-series data: "anecdotal"?

As for the case of Brazilian Amazonia, my 1980 estimate of deforestation is precisely 100 times higher than Simon calculates from my data. Could Simon simply have got his decimal point wrong by two places?—and could he suppose that the deforestation of Amazonia at the present (actual) rate would take all of 20 000 years?

Simon's overall judgment, derived from his reading of the 1982 report from the Food and Agriculture Organisation (FAO), is that tropical deforestation is no big concern. Yet the bottom-line conclusion of the FAO report reads "One thing is certain: the situation in general is serious, and for some countries it is already critical."

As for extinctions, consider Madagascar. The island once

harboured 200 000 species, 60 per cent of them endemic, the great majority of them in its eastern strip of primary forest. Of this forest, 93 per cent is gone. Simon claims there is no systematic empirical evidence for a relationship between rates of deforestation and loss of species. But island biogeography demonstrates through a multitude of analyses from all parts of the world, that when a habitat loses 90 per cent of its extent, it loses half its species. Madagascar scale figures for species totals, endemism and deforestation apply equally to forest tracts along the Atlantic coast of Brazil and in western Ecuador. In these three areas alone, there must have been numerous extinctions already.

Simon urges that before we engage in "expensive" campaigns to save species, we should look at the costs and benefits in terms of human welfare. Simon offers no analysis himself, economist though he claims to be. But environmentalists' calculations demonstrate that projected extinctions of plant species in the US during the past 16 years of this century could well cost Americans \$3.3 billion per year just in plant-based drugs foregone. By contrast, the cost of saving millions of tropical-forest species through additional protected areas, need be—according to Task Force of the World Bank and the World Resources Institute—no more than \$60 million per year.

Surely, your readers can expect

a less cavalier treatment of an issue that is exceptionally significant. If a mass extinction occurs during the next few decades along the lines anticipated, it will rank as the greatest extinction spasm of its kind since the first flickerings of life almost four billion years ago. There is an unusually strong and broadscale consensus among biologists about the scope of this impending spasm of extinction—as witness the conclusion of the recent Conference on Conservation Biology, which assembled more than 100 scientists from around the world, with their thousands of years of on-ground experience in tropical forests. A main note of dissension: the Myers estimate of the current extinction rate is too cautious and conservative.

Simon believes that mammals and birds serve as an indicator of overall extinction rates (see the table in his article). Yet he also believes—as revealed at a public debate with this writer at the US National Academy of Sciences in Washington DC—that mammals and birds make up roughly half of all species. This "estimate" is off target by a factor of at least 400.

But what else might one expect from a professor of marketing who reveals his understanding of natural sciences generally when he asserts in his scientific writings that we need not fear shortages of say, copper, since it "can be made from other metals." Yet in his *New Scientist* article he urges that

here should be a presumption in favour of statements that lead to the facts as best we know them, especially in a scientific context."

Norman Myers
Headington
Oxford

Eureka!



Ergonomic theory must be lacking in its understanding of human beings. I cannot imagine anyone sitting, or lying in a bath, with his back bent as in the illustration in your issue of 15 May (Review, p 68).

Barry M. Garraway
Sale
Cheshire

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The Northern Division headquarters of the United Kingdom Atomic Energy Authority is based at Risley, near Warrington, Cheshire. Much of our work in support of the development of economic generation of electricity by nuclear means, is highly innovative and must be considered for patent action.

As a Patent Information Officer, providing essential technical support for our Patents Officers, your key responsibilities will involve keeping under review relevant information published in patent literature both in the UK and overseas; providing current awareness services; and conducting on-line searches of computer databases to assess the novelty of possible patent subjects. The compilation of patent schedules in support of commercial agreements and the use of computer stored data on the Authority's patent holding will also fall within your sphere of duties.

The role demands a HNC, HTEC or a degree in a scientific or engineering subject, or membership of an appropriate professional institution. You

should be capable of analysing technical data and published work with a view to conducting novelty searches using computer-based techniques; some familiarity with patent literature and data would be an advantage.

Starting salary will be up to £11,280 (currently under review) depending on qualifications and experience. Other benefits include a first-class superannuation scheme, over 4 weeks' holiday, 10½ days' public and privilege holidays and flexible working hours.

Risley is in an attractive location, adjacent to the M6 and M62 and easily accessible from Lancashire, Cheshire, Greater Manchester or Merseyside.

For an application form, please write quoting reference S2907, to the Staff Officer, UK Atomic Energy Authority, Northern Division, Risley, Warrington WA3 6AT, or telephone Warrington (0925) 573160, our 24 hour answering service, or Warrington (0925) 31244, ext 2605 or 2649, for an application form.



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Nuclear power development for the nation's needs.

Gower

MEDICAL PUBLISHING

We have an immediate vacancy for a project editor in medical books. Applicants should be medical science graduates who preferably, but not necessarily, have editorial experience. Please apply with CV to Ms S Wong, Gower Medical Publishing, 34-42 Cleveland Street, London W1P 5FB.

UNIVERSITY OF LEICESTER Department of Microbiology RESEARCH ASSISTANT

Applications are invited for the above post to work on a project investigating the antimicrobial systems of macrophages.

This position, which is funded by The Wellcome Trust, will be for three years. Salary will be on Grade 1B of the research assistant scale.

Applications, including a cv and the names of two referees, should be sent to Dr P. W. Andrew, Department of Microbiology, University of Leicester, University Road, Leicester LE1 7RH, as soon as possible.

EDUCATION LIAISON OFFICER

to be second in command on conservation project for North Devon. Degree or teaching certificate in biology/ecology with teaching experience and own transport an advantage. Part time post 24 hours £2.96 per hour £71.04 gross weekly. Ilfracombe Community Programme Working for North Devon. Applicants must satisfy the rules for community programme and be in receipt of unemployment/supplementary benefit. Contact John Williamson or Bill Murtha for details. Tel Ilfracombe (0271) 66349 or 66760.

Research Assistant

Flexible Fin Propellers

A Research Assistant is required for a fixed term contract to investigate the use of Flexible Fins for the Propulsion of Marine vehicles. The initial objectives of the project are to study the operation of Fin Propellers, with a view to achieving the most efficient design of model and test rig. Select suitable materials for the construction of these models and then carry out tests.

Applicants should have a good degree or equivalent in a suitable discipline: students expecting to graduate in Summer 1986 may apply. Salary will be in Grade 1B (£7055-£9495) or Grade 1A (£8020-£9495) for Research and Analogous staff, according to age and experience.

For further details please contact: Glasgow Marine Technology Centre, University of Glasgow, Glasgow G12 8QQ.

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Opportunities in Medical Diagnostics

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Continued expansion of our Research & Development Division has created the following new posts:

Biochemistry.

Three scientists are needed for our Clinical Chemistry Group which is responsible for developing novel monoclonal antibody-based immunoassays for use in endocrine laboratories. Responsibilities will include selection of suitable monoclonals, assay optimisation and clinical validation studies. Applicants should be graduates with at least 2 years' relevant experience of the use of immunoassay in endocrinology or related disciplines. A higher degree (PhD or equivalent) will be an advantage. (Ref: SGD)

Microbiology.

We need two scientists for our Microbiology Group working as part of a team developing novel diagnostic assays. The successful candidates will be recent graduates or equivalent and will have expertise in microbiological techniques. Experience in biochemistry and immunology will be a distinct advantage. (Ref. MM)

Hybridoma.

An experienced graduate or equivalent is required for our Hybridoma section. The successful candidate should have expertise in immunology and tissue culture and will be involved in the production and evaluation of monoclonal antibodies. (Ref: KOH)

Enzymology.

A scientist is required to join our New Technology Group to work on the development of novel non-isotopic immunoassays. Applicants must be qualified to PhD or equivalent level and be able to demonstrate a proven capacity for innovative research. Preference will be given to those candidates with expertise in enzyme kinetics and active-site chemistry. An interest in protein engineering would be advantageous but experience in immunoassay is not necessary. (Ref: MP)

We offer competitive salaries, 23 days paid leave, contributory pension/life assurance scheme and relocation where appropriate.

Please apply in writing stating Ref. Code with full career and salary details to: Denise Tullett, Personnel Manager,

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St Bartholomews Hospital MEDICAL PHYSIC/ PHYSIOLOGICAL MEASUREMENT TECHNICIAN

Anaesthetics Laboratory

Training in patient monitoring techniques including the use of intravascular pressure measuring equipment, blood gas analysers, ion selective electrode systems and intra aortic balloon pumping will be given.

These services are covered by a 24 hour on-call system in which the person appointed would eventually be expected to participate.

You will be encouraged to participate in research projects associated with the Anaesthetics Department and the Intensive Care Unit.

MPT IV Salary: £6786-£8564 inclusive. Minimum qualifications are 2 Science A-Levels with relevant experience.

PMT: £6224-£7649 inclusive. Minimum qualifications are OTEC in Medical Physics and Physiological Measurement.

To arrange an informal visit please contact Mrs A. Wright on 01 600 9000 Ext 2458.

Application forms can be obtained from the Personnel Department on Ext 3188 quoting reference R/428.

NORTH EAST THAMES REGIONAL HEALTH AUTHORITY

TECHNICIAN

A technician is required for the NETRHA Pharmaceutical Microbiology Laboratory which provides a quality assurance service to hospitals in the Region.

Based at St Bartholomew's Hospital, the post offers an unusual opportunity to specialise in an interesting area. Previous experience in pharmaceutical microbiology is desirable but candidates from pharmaceutical or microbiological backgrounds considered.

Salary: £5844-£7258 Inclusive of London Weighting.

For further details ring: Dr Baird 01 600 9000 Ext 2182. Application form and job description available from the Personnel Department, St Bartholomew's Hospital, London EC1 Tel 01 600 9000 Ext 3188 quoting ref R/472.

Closing date: 2 weeks from appearance of advert.

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JUNIOR B TECHNICIAN

required to assist with running practical classes covering a wide range of Medical Sciences.

Full training will be given. Day release for further education will be encouraged.

Applicants should have at least four GCE O levels (including Maths and English) and two A levels in Science subjects. Salary according to age on the scale £3820-£5325 plus £1133 London Allowance a year.

Application forms may be obtained from the Personnel Office, Royal Postgraduate Medical School, 150 Du Cane Road, London W12 0HS, quoting Ref: 9/102/NS.

Closing date: 13 June, 1986.





The King Faisal Specialist Hospital & Research Centre Riyadh, Saudi Arabia

Research Opportunities

The King Faisal Specialist Hospital, a 500 bed acute care facility, is currently seeking qualified personnel for the following positions in the Research Centre:

Scientists, Biological and Medical Research

- A) Ph.D and 15 years experience including molecular biology techniques applicable to human biochemical genetics. Proposed topics of research include studies of inborn errors of metabolism, insulin gene polymorphisms, and oncogenes in leukemia, lymphomas and other human tumours.
- B) MSc (minimum 7 years experience) or Ph.D (minimum 5 years experience)
- 1) Prefer an interest in receptor biology, mechanisms of hormone action and/or intracellular regulatory mechanisms with experience of immunolocalisation or in situ hybridisation techniques. Possible topics of research could include tumour biology, thyroid disease, diabetes mellitus, reproductive biology, or cellular interactions within the immune system.
 - 2) Experience preferred in work on electrophysiology of the heart and electrophysiological techniques including voltage clamping and other intracellular investigational techniques.

Research Biologist

Ph.D in Biological and/or Physical Science with a minimum of 5 years research background in Radiation Biology, or, MSc/BSc and 7 years experience. Familiarity with Mammalian Cell Culture techniques with emphasis on Clonogenicity Assay and experience with experimental animals.

Senior Research Technicians

BSc or professional technical qualification, i.e. FIMLS, with 5 years experience in research or other relevant setting, or MSc and 2 years experience. Experience required in one or more of the following fields: protein isolation, characterisation and sequencing, and/or, peptide synthesis and ligand labelling. Available topics of research include, respiratory allergens, thyroid proteins, lymphokines, cytokines and growth factors, connective tissue proteins, oncogene products and lipoproteins.

Living and working conditions are excellent, and we offer an attractive benefit package which includes:

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Salary c. £7,000—£11,000 p.a.

Applications are invited for the above posts which will be based in the Warrington area.

The successful applicants will be required to assist in the collection, processing and use of data for the management and protection of relevant surface waters and will be given experience in a wide range of technical work, especially hydrological and scientific investigations.

The minimum qualification for each post is a Degree or equivalent in a natural or environmental science, or civil engineering, and the ability to undertake investigative project work, including technical report writing will be necessary.

For the Scientific posts (2), applicants must be physically capable of undertaking field survey work and be in possession of a current clean driving licence. Experience in computer based handling and processing techniques would be an advantage.

For the Hydrological post, experience in computer programming and mathematical modelling techniques is necessary. A Post Graduate qualification in Water Resources/Hydrology would be an advantage.

Closing date: 13th June, 1986.

Salary levels will be according to qualifications and experience.

The Authority is an equal opportunity employer.

Application forms and further details are available from:
Personnel Officer, North West Water, Head Office,
Dawson House, Liverpool Road, Great Sankey,
Warrington, WA5 3LW. Telephone: Penketh
(0925 72) 4321 ext. 33806.



UNIVERSITY OF NOTTINGHAM

Department of Metallurgy & Materials Science

TEACHING FELLOWSHIP

The University is seeking to appoint a teaching fellow to undertake teaching relinquished by a staff member who has been awarded a Senior Research Fellowship. The department has an integrated Materials Science Course with options in the first year permitting specialisation. The teaching fellow would be required to teach basic Metallurgy and Materials Science and could also teach a final year specialisation related to his/her research interests. An interest in ceramics, polymers or materials processing would be particularly welcome.

Further particulars and application forms, returnable not later than 16 June, 1986, from the Staff Appointments Officer, University of Nottingham, University Park, Nottingham NG7 2RD. Ref No. 1041.

DURHAM UNIVERSITY

Department of Chemistry

Applications are invited for a POSTDOCTORAL SENIOR RESEARCH ASSISTANTSHIP

tenable for two years, to work with Dr D. Parker on macrocyclic coordination complexes conjugated to monoclonal antibodies for use in cancer therapy. Applicants should either have a strong background in inorganic chemistry (particularly bio-inorganic chemistry) or have experience in macrocyclic or coordination chemistry. The project is in collaboration with Celtech Ltd, and the starting salary will be up to £9000 on Range 1A, plus superannuation (under review).

Applications (three copies) naming three referees should be sent by 10 June, 1986, to the Registrar, Science Laboratories, South Road, Durham DH1 3LE, from whom further particulars may be obtained.

UNIVERSITY OF HULL

POSTGRADUATE RESEARCH OPPORTUNITIES IN THE DEPARTMENT OF CHEMISTRY

Applications are invited for SERC and other research studentships. Areas in which the department has special interests and an international reputation include (a) liquid crystals and organic electro-optical materials, (b) heterogeneous catalysis and surface chemistry, (c) analytical chemistry, (d) combustion and laser chemistry, (e) bacterial polysaccharides, (f) organometallic chemistry. CASE awards with British Gas (Dr Moyes, catalysis), Marconi (Prof Gray, liquid crystals), ICI Mond Division (Drs Holbrook and Oldershaw, laser chemistry), and Shell (Dr Walker, combustion) are available, together with an SERC earmarked award (Dr Oldershaw) and an EEC-funded position (Dr Walker, postgraduate/postdoctoral). For further details and an application form write to Prof G. W. Gray, FRS, Department of Chemistry, University of Hull HU6 7RX.

THE LONDON HOSPITAL (WHITECHAPEL)

Department of Clinical Immunology

JUNIOR 'B' OR BASIC GRADE MEDICAL LABORATORY SCIENTIFIC OFFICER

£4915-£9610 pa inclusive

The department carries out investigations into most aspects of Immunochemistry, Cellular Immunology and Autoimmune Serology as a service requirement to a busy teaching hospital. Opportunities for further education and training in preparation for higher qualifications leading to Fellowship of the Institute of Medical Laboratory Sciences are available.

For an application form, please contact The London Hospital (Whitechapel), Clinical Laboratories on 01-377 7000, Ext 2517.

Closing date: 16 June, 1986.

CAMBRIDGE HEALTH AUTHORITY

Addenbrooke's Hospital

POSTDOCTORAL SCIENTIFIC OFFICER

required to join a MRC funded Research project into the use of cultured keratinocytes in the treatment of surgical patients. The work will be carried out in the laboratories of the Department of Dermatology.

Applicants should have tissue culture experience and PhD in a related subject.

The post is tenable for an initial period of 2½ years.

Salary: £10 032-£10 908 pa.

Further information from Dr Pye, Cambridge (0223) 245151, Ext 501.

Applications, including full cv and names of three referees, should be sent to Dr Pye, Department of Dermatology, Addenbrooke's Hospital, Hills Road, Cambridge CB2 2QQ.

Closing date: 12 June, 1986.

MEDICAL MOLECULAR BIOLOGY UNIT

Courtauld Institute of Biochemistry The Middlesex Hospital Medical School

(University of London)

London W1P 7PN

TECHNICIAN (MLSO)

Applications are invited from graduates in the Biological Sciences for the above tenured position available from 1 June, 1986. Applicants should have an interest in the application of recombinant techniques to the study of human disease, and preferably some experience in tissue culture microbiology or recombinant DNA techniques. The appointment will involve research and routine duties in a large active and productive research laboratory. Salary in the range £7141-£9610 pa. Applications, including cv and the names of two referees should be sent to: Prof R. K. Craig at the above address.

NATURE CONSERVANCY COUNCIL

HIGHER SCIENTIFIC OFFICER BSBI Monitoring Scheme two year contract

A vacancy exists for a Scheme Organiser for the above project based in Monks Wood Experimental Station for a period of two years commencing in August 1986. The project will be financed by NCC and run by the Botanical Society of British Isles. The Scheme Organiser will be responsible to a Steering Committee and the duties will include preparation of plans; instructions and liaison with the Society's staff; preparation of computer files, circulation and presentation of results for publication to the Steering Committee.

Qualifications: Applicants should have a first or second class degree in a relevant subject and at least two years post graduate experience. A good knowledge of British flora, a pleasant personality and an ability to work with volunteers is required.

Salary: within the range £7780 to £10 541, depending upon qualifications and experience.

Application forms and further particulars are available from Personnel 1, Nature Conservancy Council, Peterborough PE1 1UA. The closing date for completed applications is 25 June, 1986.

COLEG PRIFYSGOL GOGLEDD CYMRU

University College of North Wales, Bangor

School of Ocean Sciences

RESEARCH ASSISTANT

SALARY: £7055-£9495 pa

Applications are invited from graduates of a physical, geo-physical or mathematical science with experience of computing for an NERC sponsored project to investigate the nature and dynamics of upwelling filaments and fronts off Portugal. The work will involve computerised analysis of remotely sensed and in situ oceanographic data. The position is available for two years from 1 August, 1986.

Applications (two copies), giving details of qualifications and the names and addresses of two referees, should be sent to the Staffing Officer, University College of North Wales, Bangor, Gwynedd LL57 2DG, from whom further particulars may be obtained.

Closing date: 16 June, 1986.

THE UNIVERSITY OF LIVERPOOL

Institute of Medical and Dental Bioengineering and School of Dental Surgery

TECHNICIAN GRADE 5 (TWO POSTS)

Required to work in the area of new dental materials. These posts would suit either candidates with experience in the mechanical and physical testing of materials (including some electron microscopy), or those with experience of dental technology including model making.

Candidates must possess ONC or appropriate equivalent as a minimum qualification plus seven years appropriate experience.

These posts are available until 31 August, 1987 in the first instance.

Salary within range £6927-£8088 pa. (Under review).

Application forms may be obtained from The Registrar (NAS), The University, PO Box 147, Liverpool L69 3BX.

Quote ref: PER/966/NS.

SCIENTIFIC RESEARCH OPPORTUNITIES

Rock and Fluid Physics

Schlumberger Cambridge Research, established in 1982, carries out fundamental and applied research for the oilfield services companies within the Schlumberger corporation - a world leader in the energy industry and one of the largest multi-national corporations. Housed in impressive, purpose-built premises on the outskirts of Cambridge, the centre benefits from extensive contacts with the University and is equipped with a unique drilling test station and with outstanding laboratory and computing facilities.

Two opportunities have now arisen for accomplished research scientists to join our Rock and Fluid Physics department and contribute to the work being undertaken in the following areas:

Colloid/Surface Science

This is an opportunity to help us further our understanding of the interaction of colloidal oilfield fluids and porous rocks and we anticipate that you will be qualified in Physics, Physical Chemistry or Chemical Engineering and will have research experience in experimental colloid/surface science. Experience in the filtration/rheology of particulate systems or in interparticle or particle/surface energetics would be highly advantageous. Ref: RFP/6/NS.

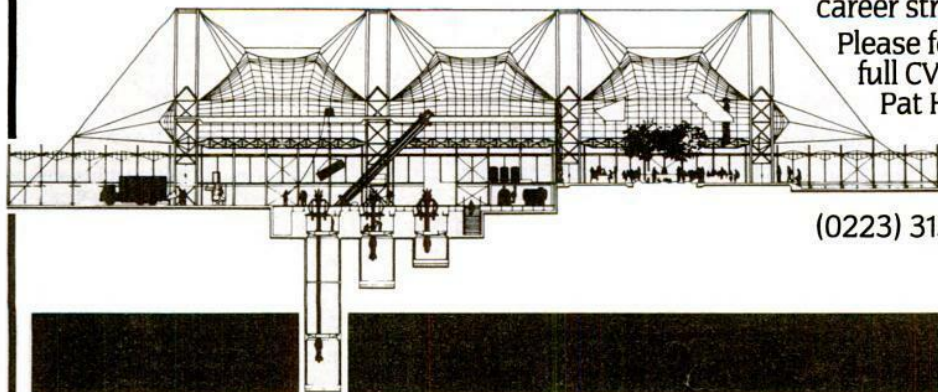
Chemomechanics

Probably qualified in Physics or Physical Chemistry, you will appreciate this opportunity to undertake innovative experimental and theoretical research into the mechanical and microstructural response of clay rocks to their chemical environment. Experience of the ionic solid state or gel structure or fracture surface phenomena would probably be useful, but the main requirement is for a creative scientist able to find experimental approaches in a new basic research area. Ref: RFP/7/NS.

For both positions, a Ph.D. is essential and post-doctoral research experience would be desirable. Indeed, we would welcome applications from people with extensive research experience.

In return for the expertise we seek, we can offer highly attractive remuneration packages, relocation assistance where appropriate and a highly flexible, long-term, career structure.

Please forward a letter of application and a full CV, quoting reference number, to:
Pat Haynes, Personnel Manager,
Schlumberger Cambridge Research,
PO Box 153, Cambridge CB3 0HG,
or telephone Cambridge
(0223) 315576 for an application form.



Schlumberger

SCHLUMBERGER CAMBRIDGE RESEARCH

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Technologist — Refractories

As a means of maintaining and advancing our position as one of the leading companies in our fields, we are looking to appoint a qualified Technologist with high potential which can best be developed in a manufacturing based environment requiring a high level of technical involvement and input.

Ideally we are looking for a person with a good Honours Degree in a materials science or another relevant science subject (chemistry, physics, metallurgy) with several years' experience who can make a meaningful contribution to our product and process development programmes. As part of this, the person will be required to demonstrate an awareness of cost efficiency and control and an appreciation of customer application needs.

In return the position offers an attractive salary which will reflect the level of responsibilities involved together with a range of employment benefits appropriate to a major company.

Applications giving full details of experience and qualifications to date, or telephone requests for an application form should be addressed to Mr. A. Merrett, Personnel Manager, Morganite Crucible Limited, Woodbury Lane, Norton, Worcester, WR5 2PU, telephone (0905) 355631.



Morgan

THE OPEN UNIVERSITY FACULTY OF SCIENCE RESEARCH ASSISTANT IN PHYSICS

Applications are invited for a post-graduate research assistantship to undertake measurements of the reflectivity and emissivity of a variety of solid, dark materials, which could include some of interest to the solar energy and optics industries, and some of relevance in remote studies of various bodies in the Solar System.

Applicants should have (or expect to have) a good honours degree qualification in physics or equivalent that includes considerable practical work. The appointee will, if eligible, be given the opportunity to register for a higher degree.

The post is available from 1 October, 1986 for a period of two years. Salary will be on the 1B scale for Research and Analogous Staff (£7055-£9495 pa—under review) with a starting salary of £7055 pa.

Application forms and further particulars are available from Dr J. W. R. Smith (8011/2), Administrative Assistant (Science), Faculty of Science, The Open University, Walton Hall, Milton Keynes, MK7 6AA or telephone Milton Keynes (0908) 653993; there is a 24-hour answering service on Milton Keynes 653868.

Closing date for applications: 1 July.

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Applications are invited for a lecturer for biochemical research of epidemiology, clinical and experimental studies, testing the hypothesis that low dietary intake of essential acids leads to coronary heart disease.

The lecturer will be in charge of the daily running of a new and well equipped GLC laboratory, supported by experienced technical staff. Previous experience in the field of (analytical) biochemistry and gas chromatography is an advantage. The successful candidate will work in collaboration with a senior lecturer in biochemistry and several cardiologists.

The position is supported by a British Heart Foundation endowment to the University of Edinburgh. Salary £7746-£15 373 and University conditions of employment apply.

Applications with cv before Monday 16 June, to:

Dr R. A. Riemersma
Cardiovascular Research Unit
University of Edinburgh
Hugh Robson Building
George Square

Please Quote Reference No 1256.

UNIVERSITY OF EXETER DEMONSTRATOR IN PHYSICAL CHEMISTRY

Applications are invited for a Demonstratorship in Physical Chemistry, tenable from 1 October, 1986, or as soon as possible thereafter, for a period of two years. Applicants should have a good Honours Degree in Chemistry and/or a PhD.

Salary depending on qualifications:

	Predoctoral	Postdoctoral
First year	£7055	£8020
Second year	£7530	£8505

In addition to teaching duties, the successful candidate will be expected to pursue an active research programme.

Further particulars may be obtained from the Personnel Office, University of Exeter, Exeter EX4 4QJ, to whom applications (five copies) giving the names of two referees, should be sent by 20 June, 1986, quoting reference no. 3469.

UNIVERSITY OF LEICESTER Department of Chemistry POSTDOCTORAL RESEARCH ASSOCIATESHIP

Applications are invited for a Research Associateship, funded by the SERC, to work with Dr P. M. Cullis, on studies of Chemical and Enzyme Catalysed Phosphoryl Transfer Reactions. Applicants should have a background and interest in synthetic and mechanistic organic chemistry.

The appointment, from 1 October, 1986 will be for a period of one year. Salary within the range £8020-£9495 on the 1A scale (under review from April 1986) with USS.

Applications including a cv and names and addresses of two referees should be sent as soon as possible to Dr P. M. Cullis, Department of Chemistry, The University, Leicester LE1 7RH.

UNIVERSITY OF OXFORD University Laboratory of Physiology DEPARTMENTAL DEMONSTRATORSHIP Salary £7055-£9880 (National Lecturership Scales)

The Department of Physiology invites applications for a Departmental Demonstratorship, to be named the EPA Cephalosporin Demonstratorship. The initial appointment will be for three years with the possibility of renewal for a further period not exceeding three years. Departmental Demonstrators take part in the teaching of physiology to medical and non-medical undergraduates, but ample time is available for them to conduct their own independent research, the expectation being that this will be within one of the existing areas of work in this Department.

Applications (three copies) including the names of two academic referees (who have agreed to communicate their views without further request) to: Dr G. Gordon, University Laboratory of Physiology, Parks Road, Oxford OX1 3PT, from whom further particulars are available.

CAMBERWELL HEALTH AUTHORITY

**Haematology
QUALIFIED OR JUNIOR
'B' MLSC**

For our busy Department involved in service, teaching and research. If you are State Registered, you will be encouraged to study for the FIMLS, and there is an in-service training programme in operation.

Applicants who are eligible to commence as Junior 'B' MLSC should have a minimum of two 'A' levels, one of which must be Chemistry (plus another science/maths subject) or should possess a relevant science degree. You will be expected to study for State Registration.

Hours: 37 per week.

Salary: £7141-£9610 pa inc (qualified); £6247-£6405 pa inc (Junior 'B' at age 21).

Informal enquiries / application form from the Unit Personnel Department, King's College Hospital, Denmark Hill, London SE5 8RS, Tel 01-274 6222 Ext 2751, quoting Ref: B16476.

Closing date: 13 June, 1986.

University of East Anglia Norwich

SENIOR RESEARCH ASSISTANT

Applications are invited for a two year postdoctoral appointment for an SERC funded project in the School of Biological Sciences, on the function and structure of lens gap junction protein channels in planar bilayer membranes and liposomes, beginning 1 October, 1986, or as soon as possible thereafter. Salary within the R & A Range 1A £8020-£12 780 pa.

Informal enquires may be made to Dr E. J. A. Lea, School of Biological Sciences, University of East Anglia, Norwich, NR4 7TJ, Tel 0603 56161 Ext 2258, to whom applications should be sent.